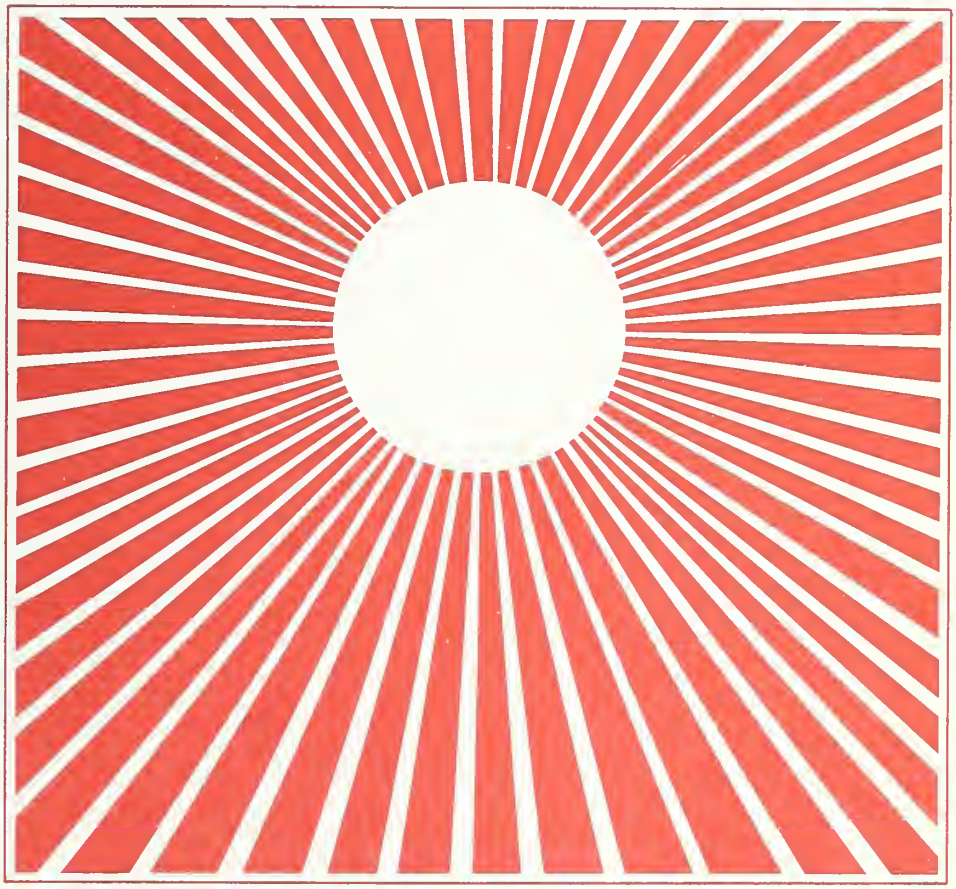
SOLAR ENERGY AND NONFOSSIL FUEL RESEARCH

A Directory of Projects Related to Agriculture
1976–79



UNITED STATES DEPARTMENT OF AGRICULTURE

SCIENCE AND EDUCATION ADMINISTRATION

MISCELLANEOUS PUBLICATION No. 1378

SOLAR ENERGY AND NONFOSSIL FUEL RESEARCH

A Directory of Projects Related to Agriculture 1976–79

Compiled by
SMITHSONIAN SCIENCE INFORMATION EXCHANGE, INC.
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UNITED STATES DEPARTMENT OF AGRICULTURE

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FOREWORD

Man lives by the sun. Its rays provide him with light and heat. The sun generates the energy which sustains all living things to produce abundant food and fiber across this rich land. Equally important, the sun has helped create the plentiful amounts of fossil fuel needed to bring about the modern miracle of American agriculture.

Over the long span of ages, the animal and vegetable life of this planet has died, decayed, and been converted by natural processes to the coal, oil, and gas that has provided the lifeblood of our energy-dependent economy. For centuries we have been awash in these abundant, but non-renewable fuels, tapping the huge resources in the earth around us.

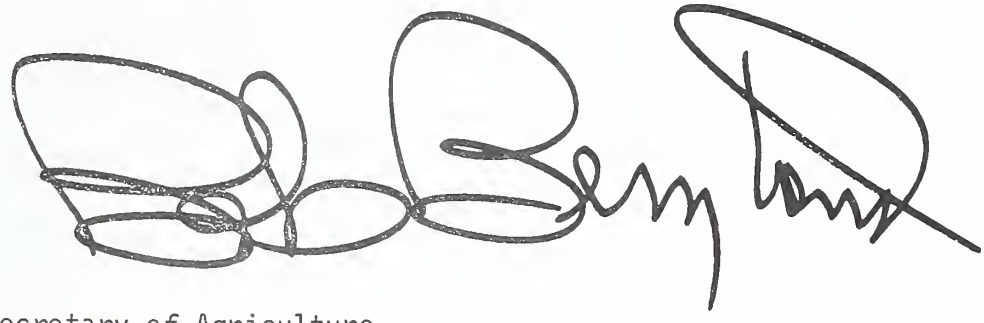
Suddenly, the availability of oil and gas is no longer assured, threatening to undermine the fabric of our society—the way we work, and play, and live. A basic question is: Can we afford an energy shortage capable of crippling our agricultural economy—the ability to feed ourselves and much of the rest of the world? The answer must be a resounding NO.

Conservation can be helpful, but a dynamic, healthy, productive Nation demands that we seek alternate energy sources. These sources must be renewable, under our control, and available at a reasonable price.

One solution to this crisis could, in fact, be heaven-sent: from the sun where it all began.

Solar Energy and Nonfossil Fuel Research is a directory of projects related to agriculture. It is a chronicle of man's intensified search from 1976 to 1979 for those alternate energy sources. Its pages contain a compilation and description of Federal, State, and private research efforts designed to harness solar radiation directly for energy purposes and to develop such diverse energy sources as methane from plant and animal wastes, alcohols from plant materials, power from windmills, geothermal heat for homes, greenhouses, and other buildings, and firewood.

This directory—the first annual compilation of agriculture-related solar energy research—is designed to provide the scientist, technician, and inventor; government and industry; and farmers and other interested laymen with an overview of the diverse and intense efforts being mounted by our society to find alternate energy sources. The results may determine not only whether we can continue to feed ourselves, but the ultimate shape of our world.



Secretary of Agriculture

PREFACE

The Food and Agriculture Act of 1977 (Public Law 95-113), Section 1450, calls for an annual compilation of agriculture-related solar energy and nonfossil fuel research projects. This directory, Solar Energy and Nonfossil Fuel Research, was prepared by Technical Information Systems (TIS) of the Science and Education Administration (SEA), U.S. Department of Agriculture, in response to that requirement.

The Smithsonian Science Information Exchange (SSIE) data base and computerized system capability was used in the preparation of the directory. The major source for this first compilation, which includes 814 projects active from 1976 through early 1979, was the SEA/TIS Current Research Information System (CRIS). SEA/TIS is appreciative of SSIE's cooperation in identifying relevant projects, compiling the list of project descriptions, and preparing the corresponding indexes.

Consistent with the provisions of Section 1450 of the Food and Agriculture Act of 1977, topics covered in this compilation pertain to solar energy and nonfossil fuel research and its application to agriculture and the rural environment. Studies relating to farm operations, structures and equipment, as well as those applicable to farm dwellings are included.

The first section of the directory consists of descriptions of research projects and is divided into three chapters. Chapter 1, Solar Energy Applications, contains projects dealing primarily with the use of solar radiation as a direct energy source. Chapter 2, Energy Production from Biomass, includes projects on the production of liquid or gaseous fuels from plant materials and agricultural wastes, the production of biomass for the specific purpose of producing a source of organic matter for methane or alcohol production or for direct combustion, and a few select projects dealing with solar radiation and photosynthetic mechanisms in which the potential for the development of "energy farms" or "energy plantations" is suggested. Chapter 3, Utilization of Geothermal, Wind, or Other Nonfossil Energy Sources, contains research projects concerned with technologies receiving renewed attention. Included in this chapter are two projects on the recovery and reuse of biological heat from animals or animal products such as milk.

Access to the project descriptions is also provided through four indexes. These are arranged by keyword, investigator, performing organization, and supporting agency.

In the process of registration of research projects with SSIE, two or more reports for the same project are sometimes received from different agencies. These represent projects which are multisupported or receive "pass-through funds" (work funded by one agency but performed by another). Specific attempts were made to identify and remove this duplication, but in cases where multiple submissions for the same project contain variations in the project description or show different project, contract, or grant numbers, they are included as separate entries.

Due to the intense public interest and current concern for new energy alternatives, copies of this directory are being widely distributed and made available from several sources. Users in USDA, State cooperating institutions, and other governmental agencies may obtain free copies by sending a self-addressed mailing label with their request to: Library Services Division, SEA/TIS, U.S. Department of Agriculture, National Agricultural Library Bldg., Beltsville, Maryland 20705. The public may obtain copies through the Superintendent of Documents, U.S. Government Printing Office (GPO), Washington, D.C. 20402.

Published literature is extensive on this subject in the form of journal articles, technical reports, and books, and should be considered an adjunct resource of this listing. Citations to this literature can be retrieved by searching AGRICOLA (Agricultural On-Line Access) through on-line commercial services. An additional specialized bibliography of 2,613 citations for 1973 through May 1976 issued by Michigan State University is being incorporated into the AGRICOLA system. The bibliography is:

> Energy for Agriculture: A Computerized Information Retrieval System, compiled by B. A. Stout and C. A. Myers, Agricultural Engineering Department, Michigan State University, Seventh Edition, July 1979

A free copy of this bibliography may be obtained by sending a self-addressed mailing label with the request to Library Services, SEA/TIS, at the same Beltsville address listed for the directory.

Information on many of the projects listed in this directory, as well as others dealing with agricultural energy topics, is contained in the CRIS computerized data base at SEA/TIS and in the commercially available CRIS on-line file. For additional information on access and availability through either the in-house or on-line system contact: Current Research Information System (CRIS), SEA/TIS, U.S. Department of Agriculture, National Agricultural Library Bldg., Beltsville, Maryland 20705.

SEA/TIS solicits your comments on this first directory. Please submit your suggestions to: Project Manager, Solar Energy Directory, Agricultural Information Division, SEA/TIS, U.S. Department of Agriculture, National Agricultural Library Bldg., Beltsville, Maryland 20705.

CONTENTS

USER GUIDE
SAMPLE PROJECT DESCRIPTION

Directory Number 1.0319

Chapter Number

Sequence within Chapter

Project Title — ENERGY EFFICIENCY AND UTILIZATION IN AGRICULTURAL PRODUCTION

Principal Investigator, Performing Organization and Address — *M. A. Hellickson,* South Dakota State University, Agricultural Experiment Station, Dept. of Agricultural Engineering. *Brookings, South Dakota* 57006

Project, Grant or Contract Number — (SD00754)

Project Summary

OBJECTIVE: Evaluate systems for more efficient use of electricity, fossil fuels, and other energy sources for agricultural production. Determine energy requirements for performing selected agricultural operations in South Dakota. Investigate methods of substituting energy sources, such as solar and wind, for agricultural systems currently using conventional energy sources. Study the effects of management and control on energy use for agricultural production.

APPROACH: Cold air crop drying and solar supplemented crop drying studies will be conducted on the Agricultural Engineering Farm. Low temperature, low cost solar collectors will be investigated as a source of supplemental heat for confinement livestock buildings. Work will be performed to develop a multipurpose solar-intensifier-thermal storage system for agricultural uses.

PROGRESS: A computer simulation model, based on required ventilation rates, building characteristics and livestock environmental considerations, was developed. For Brookings, South Dakota, climatic conditions an overall thermal resistance value of approximately 12 Hr-ft F/Btu is optimum at current energy and insulation prices. Data have been developed on energy costs for typical months of operation and for the effects of livestock density and environmental temperature. A $45,000 research grant was received from ERDA to study a solar energy-intensifier-thermal storage system for drying agricultural products and for agricultural space heating. Studies of selected types of low cost, low temperature rise solar collectors, mounted on the southern two-thirds of conventional shelled corn drying bins, indicate that bare collectors can be as efficient as covered flat-plate collectors. Economics and energy savings have been noted for solar supplemented versus conventional low-temperature corn drying. Data have been collected on the performance of three geometric configurations of low cost, low-temperature rise solar collectors used to provide supplemental heat for a closed confinement beef building.

Supporting Agency — SUPPORTED BY South Dakota State Government

ARRANGEMENT OF ENTRIES

Projects in this directory are listed by chapter and assigned unique identification numbers for locating project descriptions referenced in the indexes.

The DESCRIPTION OF RESEARCH PROJECTS contains all the project summaries alphabetically arranged within each chapter by State, performing organization, and principal investigator. Within this sequence each project is assigned a unique five-digit number (i.e. 1.0319) indicating the chapter (left digit) and the position in the chapter (right four digits) in which the summary is located. A project which contains elements applicable to more than one chapter is placed in the first appropriate chapter.

The SUBJECT INDEX is based on a classification system developed by SSIE in which index terms are arranged in hierarchies reflecting relationships between broader and narrower subjects. To avoid proliferation with excess entries and group-related items, highly specific terms, in many instances, are subsumed or appear under those at the next higher generic level. A maximum of three levels are provided in the index. "See" and "See Also" cross-references are included to assist in locating topics. Each index term is followed by the project title and the unique five-digit number for locating the project summary, as in the following example:

ENERGY UTILIZATION
Energy Conservation
EFFICIENCY AND UTILIZATION IN AGRICULTURAL PRODUCTION 1.0319

To further aid the reader, the subject index is arranged in a dictionary format in which the first and last main headings on opposite pages also appear in the top margins.

The INVESTIGATOR INDEX is an alphabetical listing of all investigators cited on the source document provided to SSIE. An asterisk is used to designate the principal investigator, and only this name appears in the project description.

The PERFORMING ORGANIZATION INDEX lists, alphabetically, the name of the institution or laboratory actually conducting the investigation.

The SUPPORTING AGENCY INDEX consists of a single alphabetical listing of both Federal and non-Federal sources of support.

DESCRIPTION OF RESEARCH PROJECTS

SOLAR ENERGY APPLICATIONS

1.0001,
EVALUATION OF A CLOSED SYSTEM AND USE OF SOLAR POOLS FOR THE CULTURE OF FISH, SHELLFISH AND AQUATIC PLANTS

R. Allison, Auburn University, Agricultural Experiment Station, Dept. of Fisheries & Allied Aquaculture, *Auburn, Alabama* 36830 (ALA00399)

OBJECTIVE: Maximize animal protein production from a fed fish population in a closed system through the use of aquatic plants, fish and shellfish grown in the effluent. Develop management plan for growing fish from recently hatched fry to harvestable size in a closed system. Determine the carrying capacity of closed systems for various sizes of food fish fingerlings.

APPROACH: Food fish populations will be grown in tanks and fed a complete diet. The effluent will be reconditioned by circulation through tanks containing populations of filter feeding fish and shellfish. It will be further reconditioned with the removal of dissolved nutrients by aquatic plants. Reconditioned water will be aerated by air blower and returned to the food fish population.

PROGRESS: Nine tanks measuring 25 feet x 29 feet x 2.5 feet were each stocked with 100 channel catfish and nine were each stocked with 200 channel catfish. Of the 9 tanks at each stocking rate of catfish, were stocked with catfish only, 3 were stocked with catfish plus 50 silver carp and 3 were stocked with catfish plus 1000 asian clams. There was no significant difference in growth among treatments stocked with 100 channel catfish. Growth in treatments stocked with 200 channel catfish was significantly greater than that of the lower stocking rate but there was no significant difference among the three treatments stocked with 200 channel catfish. Tanks measuring 24 feet x 9 feet x 2.5 feet were stocked each with 200 Tilapia and fed 64 days. At this point the populations were divided in half, restocked into tanks and fed an additional 59 days. The maximum net gain for the 123 day feeding period was 206.3 lb, the average being 161 lb. net gain per tank. The feasibility of overwintering Tilapia in solar heated ponds was demonstrated.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Alabama

1.0002,
POTENTIAL FOR CONVERSION AND UTILIZATION OF SOLAR ENERGY IN POULTRY PRODUCTION

R.N. Brewer, Auburn University, Agricultural Experiment Station, Dept. of Poultry Science, *Auburn, Alabama* 36830 (7098-20400-009-A1)

OBJECTIVE: Determine the amount and types of fuel used in the production of poultry products, and to probe the feasibility of replacing part or all of this energy requirement with solar energy.

APPROACH: Current sources and amount of heat energy used in poultry production will be determined by field surveys and analysis of industry records. An economic analysis of the impact of decreasing supply and increasing cost of energy on production costs, and the effect on consumer costs will be conducted. These data will be used to evaluate the economic feasibility of using solar energy in poultry production.

PROGRESS: Plase 1 - Design and Construction of Solar Research Facility The building is 36 ft. wide x 170 ft long, framed with steel trusses on treated 6' x 6' side posts. The exterior skin is 26 guage galvanized metal, and walls and ceiling are insulated as follows: Ceiling - 2' styrofoam rigid board; walls and partitions - 3 1/2' fiber glass bats. The research area consists of 6 rooms 20 ft. wide x 35.5 ft. long. Each room is separately ventilated and electricity, gas, fresh water and solar heat are metered and supplied independently of other rooms. The solar collectors are copper plated, double glazed, flat plate collectors built by Revere. Approximately 700 sq. ft. of collector area will be divided into 6 groups of 6 collectors. Water will be stored in three 1000 gallon steel tanks and pumped to the various research rooms through copper pipes. A weather station on site will monitor cloudiness, hours and minutes of sunshine, intensity, wind gusts, temperature, dew point and other meteorological parameters. All data will be assembled using an Esterline Angus data logger with mag storage.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Alabama - North Mississippi Area

1.0004,
THE USE OF DESSICANTS AS DRYING/HEAT STORAGE MEDIA FOR CROP DRYING BY SOLAR ENERGY

S.V. Bourgeois, Lockheed Missiles & Space Co. Inc., *4800 Bradford Dr., Huntsville, Alabama* 35807 (7090-11023-005-A)

OBJECTIVE: Identify candidate dessicant/thermal storage media which meet the requirement of crop drying systems, analyze the suitability of solar energy for regeneration and establish conceptual designs for dessicant/thermal storage media and provide process flow diagrams of promising systems.

APPROACH: The research program will be divided into two tasks. Task I will include compiling the thermochemical and physical properties of the most common dessicant materials. Both solid and liquid dessicants will be considered. The candidate dessicant/thermal storage media identified in Task I will be analyzed to determine their suitability for regeneration by solar energy. Their capabilify for dessicant and thermal storage during nighttime, cloudy or inclement weather will be considered. Flow diagrams will be provided for the promising systems and the suitability of auxiliary energy sources will be determined for each dessicant system.

PROGRESS: Analyses of the physical and chemical properties of dessicants indicate that calcium chloride and lithium chloride salt solutions have the best application in solar regenerated crop drying applications. These solutions can be regenerated at lower temperatures than other dessicants, have high specific heats and are stable, non-toxic chemicals. These solutions can cause electrolytic corrosion and require the selection of suitable materials for the fabrication of crop drying equipment. Several conceptual designs and process flow diagrams for using solar energy to regenerate solid and liquid dessicants have been produced.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0005,
ANNUAL CYCLE SOLAR REGENERATION OF DESICCANT FOR CROP DRYING

J.W. Fletcher, Lockheed Missiles & Space Co. Inc., *4800 Bradford Dr., Huntsville, Alabama* 35807 (7004-20190-016-G)

OBJECTIVE: Evaluate the performance of the solar regenerated desiccant pond concept and determine its technical feasibility and practicality. Additional objectives are to assess the economic potential of the concept and develop design criteria for a prototype system.

APPROACH: A system analysis will be performed on the proposed solar drying system to define the design conditions for the crop drying and regeneration system. Following this an experimental version will be designed, constructed and evaluated. The analysis of these tests will include an economic feasibility study and a plan for commercialization.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0006,
GREENHOUSE HEATING AND COOLING

W.R. Kruse, Lockheed Missiles & Space Co. Inc., *4800 Bradford Dr., Huntsville, Alabama* 35807 (7090-12054-004-A(2))

OBJECTIVE: Develop simulation models for solar energy systems to analytically assess the technical and economic feasibility of solar heating and cooling of greenhouses, experimentally venfy the models, and develop systems design data.

APPROACH: Utilize an existing operational solar energy computer program to develop a simulation model for optimization of the components in a solar heating/cooling system for greenhouses. Use the simulation model to determine solar energy collector design and size, energy storage size, as well as other pertinent variables which will result in minimum combined equipment and operating costs. Determine the optimum portion of total energy that should be obtained from the sun. The investigation will include the construction, instrumentation, and use of a small greenhouse to verify the results of the analytical model.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0007,
ENVIRONMENTAL IMPACT STATEMENT FOR A SOLAR POWER STATION

D.R. Sears, Lockheed Missiles & Space Co. Inc., *4800 Bradford Dr., Huntsville, Alabama* 35807 (B624B-384)

The objective of this project was to produce an example environmental impact statement for a hypothetical solar electric power generating plant.

The approach was to select a site where appropriate data were available and to impose the hypothetical situation upon it.

The output is a report simulating the environmental impact of a hypothetical 1000 MNe solar-electric plant in the desert of southeastern Nevada. Results indicate the principal impacts would be the destruction of soil and vegetation on 52 square km of desert terrain and the displacement of the animal population. There would be no effects on ground water, no thermal pollution, no surface water pollution, and no noise pollution. The visual impact would be extensive.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Industrial Environmental Research Lab.

1.0008,

SOLAR HEATING AND COOLING DEMONSTRATION - MOODY, ALABAMA

Unknown, Michael Greene Co. Inc., *Moody, Alabama*

The project is a simple two story single family dwelling design modified to include a solar heating and domestic hot water preheating system. The design contains 1,296 square feet of heated floor area not including a two car garage. An assymetrical roof provides optimum tilt for solar radiation collection as well as an extended overhang to shade the many south-facing windows from the hot summer sun. Storm windows, added insulation and a fireplace are additional energy conservation features that improve the thermal performance of the building.

SOLAR APPLICATION: HEATING AND HOT WATER

COLLECTOR: 273 square foot air-cooled flat-plate manufactured by Solaron Corporation with two sheets of tempered glass as the cover plate; south-facing windows.

STORAGE: 145 cubic feed of one and one-half inch rock within a 5'-3' x 5'-3' x 6'-9' insulated storage bin located in the lower floor.

DISTRIBUTION: Forced air, natural radiation and convection. A blower and motor driven dampers are part of the factory pre-assembled air handling module circulating heated air to occupied spaces from collector storage.

AUXILIARY ENERGY SYSTEM: Gas furnace. In-line with solar system ducts the furnace provides a full or partial energy boost as required.

DOMESTIC HOT WATER SYSTEM: Finned coil located in the air handling module preheats domestic hot water prior to placement in an insulated 80 gallon storage tank. Preheated how water passes through a conventional water heater.

COOLING: Natural ventilation.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0009,

ANALYSIS OF ADVANCED CONCEPTUAL DESIGNS FOR SINGLE-FAMILY ABSORPTION CHILLERS

R.L. Meek, Southern Research Inst., Dept. of Engineering & Applied Science, *2000 9th Ave. S., Birmingham, Alabama* 35205

Develop and analyze new concepts for absorption cycles to improve the performance and/or reduce the cost of a 3-ton absorption chiller that can be used with solar-collected heat.

SUPPORTED BY U.S. Dept. of Energy

1.0010,

APPLICATION OF SOLAR ENERGY TO INDUSTRIAL DRYING OF SOYBEANS

G.R. Guinn, Teledyne Brown Engineering Co. Inc., Energy Programs, *Cummings Research Park, Huntsville, Alabama* 35807 (EY-76-C-05-5122)

The objective of this project is to provide for the analysis, design, fabrication, testing, and demonstration of a solar energy system for process drying of soybeans. An array of 672 air collectors will be used to temper the inlet air to the existing continuous-flow dryers at the Gold Kist Soy facility at Decatur, AL. This project has been subcontracted.

BIBLIOGRAPHIC REFERENCES: Guinn, Gerald R., Soybean Drying Using Heat from Solar Energy, American Section of the International Solar Energy Society, Proceedings of the 1977 Annual Meeting, Orlando, FL, June 6--10, 1977; Fisher, Perry N. and Gerald R. Guinn, Soybean Drying Using Heat from Solar Energy, University of Maryland, Solar Industrial Process Heat Symposium, Sept. 19--20, 1977.

SUPPORTED BY U.S. Dept. of Energy

1.0011,

CULTURE SYSTEMS AND SPECIES REQUIREMENTS FOR FISH IN RESEARCH AND PRODUCTION

N.C. Parker, U.S. Dept. of the Interior, Fish & Wildlife Service, Div. of Fishery Ecology Research, Southeastern Fish Culture Laboratory, *Marion, Alabama* 36756

A fish culture system with low energy reqirements for pumping, filtration, and thermal control will be installed at SEFCL. This system will be operated throughout the year to produce fish in a controlled environment. Species environmental and physiological requirements for optimum growth, production, maturation, and spawning will be evaluated. Responses to chronic stresses i.e. stocking density, low DO, NH3, etc. associated with intensive culture will be monitored and related to species performance when subjected to acute stresses.

To achieve maximum thermal stabilization fish tanks have been placed in the ground with the water level below ground surface. With an inflow of well water at 19 C and with soil temperature remaining nearly constant, the resulting water temperature in culture system is expected to be ideal for trout and striped bass production throughout the year. Different tank width to depth ratios will be investigated to determine the optimum geometric design.

For the production of warm-water species the system will be heated by using solar collectors and the water surfaces will be protected from the cold weather by domed covers. Water-reuse will be achieved by using rotating biological disc filters and tube clarifiers to maintain water quality at acceptable levels for fish production.

SUPPORTED BY U.S. Dept. of the Interior, Fish & Wildlife Service, Div. of Fishery Ecology Research

1.0012,

WASTE HEAT UTILIZATION

B.J. Bond, U.S. Tennessee Valley Authority, Office of Agricultural & Chemical Development, *Muscle Shoals, Alabama* 35660 (F624A-090)

Task I. Soil heating to extend crop growing season--Specific objectives are (1) Heating soil to extend the crop growing season, and (2) Improving production efficiency of field and horticultural crops. Field experiments were continued in 1977 in plots of soil heated by water circulated through plastic pipes. Warmer water than used previously (43 to 49 degrees C) resulted in early spring growth response by sweet corn, snap beans, peanuts, and cantaloupes with yield increases of peanuts and cantaloupes. Experiments were also continued in a plastic greenhouse with warm water piped through the soil as the sole source supplementing solar heat. Air temperatures remained above freezing except with outside night temperatures below -18 degrees C (0 degrees F). Cold season vegetable crops were grown successfully in midwinter, but it was necessary to delay planting of warm season crops until late February.

Task II. Biological Recycling of Nutrients from Livestock Wastes--Specific objectives are: (1) Develop a method that uses waste heat from electric power plant discharge water to enhance biological recycling of plant nutrients from livestock waste by growing aquatic and terrestrial plants (2) Investigating the use of fish, clams, and/or other animals to consume the produced plants, and (3) Evaluating the use of these products as feedstuffs or livestock feed supplements. Experiments have been conducted in unheated open-air 8000-liter test pools and in heated tanks under a plastic covering. The water is heated by running warmed water through stainless steel heat exchangers. Swine manure was used to fertilize 'native' algae and other plants. Algae production has been good, but simulated waste heat temperatures were of little benefit during summer. Phytophagous fish (silver carp, bighead carp, and Tilapia) have had good survival and high growth rates when fed algae grown with swine manures. Further testing will be necessary to assess the benefit of waste heat during the winter months.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Industrial Environmental Research Lab.

1.0013,

SOLAR GRAIN DRYING COLLECTOR MODELING

A.B. Meinel, Helio Associates Inc., *8230 E. Broadway, Tucson, Arizona* 85710 (3090-15701-009-C)

OBJECTIVE: Develop a computer model for evaluating the performance of solar collectors applicable to grain drying.

APPROACH: Develop a computer subroutine that will input solar radiation data, abmient conditions, airflow, collector geometry, orientation and materials of construction and output quantity & temperature of air delivered. Adapt the solar collector model to be compatible with existing grain drying models developed in Nebraska (Thompson, 1972) and at Michigan State University (Bakker-Arkema, 1974). Assemble the program developed into a source deck in Fortran language with adequate program documentation.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Kansas - Nebraska Area

1.0014,

ARIZONA 150KWE SOLAR IRRIGATION PROJECT

J.F. Warnock, State Solar Energy Res. Comm., *Phoenix, Arizona*

The objectives of the work program are to cooperate with the Energy Research and Development Administration in the development of a 150kWe solar powered deep well irrigation facility, to prepare a competitive selection plan for a site selection for the facility somewhere in Arizona, and to prepare preliminary plans for these longer-term tasks: (a) plan and conduct agricultural experiments, (b) conduct symposia to disseminate project information and data, (c) perform cost analysis of site area farming, (d) study alternate use of solar energy for site off-season usage, (e) perform site preparation and initial construction, and (f) investigate incentives for solar irrigation in Arizona.

SUPPORTED BY Arizona State Government

1.0015,

WATER TRANSFER IN THE SOIL-PLANT ATMOSPHERE SYSTEM AS RELATED TO WATER CONSERVATION

R.D. Jackson, U.S. Dept. of Agriculture, Agricultural Research Service, Water Conservation Lab., *4331 E. Broadway, Phoenix, Arizona* 85040 (5510-20760-001)

OBJECTIVE: Determine the nature and magnitude of interrelated physical, chemical, biological and meteorological processes associated with water transfer in soil, plants and the atmosphere, with the goal of reducing water losses and of improving water use efficiency.

APPROACH: Conduct detailed theoretical and experimental laboratory and field studies concerning water, salt, heat and gas transfer mechanisms within the soil and atmosphere on a diurnal and seasonal basis. Identify key environmental properties that affect transfer mechanisms, and determine management practices that alter these properties to reduce water losses. Develop remote sensing techniques for estimating soil water content, evapotranspiration, and plant water stress over large areas for crop yield prediction, irrigation scheduling and hydrologic studies. Utilize controlled environment chambers as tools to study transpiration and photosynthesis in detail. Develop design criteria and operating procedures to maximize water use efficiency and crop yields in controlled-environment structures.

PROGRESS: Daily rates of evapotranspiration from grass, field beans, alfalfa, wheat, bare soil, and a water tank were estimated using net solar radiation, air temperature, and remotely measured surface temperatures. Remotely measured crop canopy temperatures minus air temperature above the crop taken about 1 to 1 1/2 hours after solar noon were shown to be a feasible tool for determining water requirements of wheat. The canopy-air temperature difference, when summed beginning at heading, proved to be useful in predicting wheat yields. Albedo decreased from heading to maturity, and then increased. The minimum albedo achieved just before maturity was linearly related to yield. Plant water potential measurements correlated well with the canopy-air temperature difference, indicating that the latter was an adequate indicator of plant water stress. Spectral band ratioing techniques yielded no significant information concerning changes in soil water content. A modular computer program was written to simulate the performance of energy-related devices such as thermostats, solar collectors, and greenhouses. Utilizing routine weather observation, the program computes estimates of the annual operating costs and conditions of greenhouses with many different potential energy-saving devices.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Arizona - New Mexico Area

1.0016,

ELIMINATION OF ATMOSPHERIC POLLUTION BY SULFUR DIOXIDE DURING COPPER SMELTING

J.W. Berry, University of Arizona, Agricultural Experiment Station, Dept. of Agricultural Biochemistry, *Tucson, Arizona* 85721 (ARZT-0206-4150-192)

OBJECTIVE: Develop a process for the reduction of copper ore to copper and elemental sulfur. Study certain chemical reactions involving copper sulfide, water, sulfur dioxide, hydrogen sulfide, hydrogen, and iron compounds in the range 800-1200 degrees C.

APPROACH: Copper (I) sulfide will be used as a model for copper ore and its reduction to copper and elemental sulfur will be studied under a variety of conditions. Reactions will be carried out in ceramic furnace tubes with measurement of gas velocities, composition of effluent gas mixtures, and other parameters. Relative performance of fixed-bed and fluid-bed systems will be made. Analysis will be made by chromatographic and spectrophotometric methods. The nature and extent of reaction of certain system components, such as sulfur and water, will be studied where appropriate. These data will be related to the behavior of the whole system. Reverberatory feed mix of commercial origin will be used in place of copper (I) sulfide in (1) to evaluate the process on a laboratory scale.

PROGRESS: Work was carried out in cooperation with the Chemical Engineering Department on the conversion of wood waste to useable hydrolysis and other food products. Acid hydrolysis of cellulose was studied at high temperatures and at short reaction times. A number of miscellaneous reactions were carried out for the Chemistry Department. The special equipment and skills of the High Pressure laboratory were employed in these reactions. Two proposals have been unofficially been submitted to the National Aeronautics and Space Administration. These involve recovery of solar energy. At the present time, the agency is actively engaged in studying the presentations in an effort to determine in what manner the agency might work with the University.

SUPPORTED BY Arizona State Government

1.0017,

ADDING MARKET VALUE TO HARVESTED ARIZONA VEGETABLES AND GRAIN BY PROCESSING WITH SOLAR ENERGY

R.E. Foster, University of Arizona, Agricultural Experiment Station, Dept. of Plant Sciences, *Tucson, Arizona* 85721 (ARZT-172381-56-14)

OBJECTIVE: Utilize surplus vegetables by dehydrating 'completely.' Improve shipping ability of Arizona vegetables and reduce transit costs and handling losses by removing small amounts of moisture at origin, restoring it at destination. Permit early grain harvest by artificially drying sl. immature grain. Accomplish all of above through use of solar energy.

APPROACH: Use fossil fuel to simulate solar powered dehydrator. Establish machine requirements and develop methods. Obtain harvested produce, apply drying treatments, store, restore to original form, evaluate by appropriate comparisons. Compare artificially dried grain with full term grain. Determine proper timing by comparing different ages.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Arizona

1.0018,

FEASIBILITY STUDY FOR USING SOLAR ENERGY FOR IRRIGATION PUMPING

D.L. Larson, University of Arizona, Agricultural Experiment Station, Dept. of Soils Water & Engineering, *Tucson, Arizona* 85721 (3090-12271-001-A)

OBJECTIVE: Analyze the engineering and economic feasibility of using solar energy for irrigation pumping.

APPROACH: The energy demand as a function of time for irrigation pumping will be determined from available data for the Southwest United States and confirmed with current onsite measurements. The influence of higher pumping rates from known acquifers and the performance to be expected from water pumps will be determined from available literature. The evaluated data will be supplied to Texas Tech University for use in a computer simulation model to determine the requirements of the solar energy collector system.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Illinois - Indiana - Ohio Area

1.0019,

ENERGY IN WESTERN AGRICULTURE - REQUIREMENTS, ADJUSTMENTS, AND ALTERNATIVES

D.L. Larson, University of Arizona, Agricultural Experiment Station, Dept. of Soils Water & Engineering, *Tucson, Arizona* 85721 (ARZT-2020-4151-098)

OBJECTIVE: Assess contributions of, and prospects for, alternative technologies and policies for dealing with changes in energy availability.

APPROACH: An energy balance model (digital computer) will be developed to analyze the energy expended in each of the production operations normally used in Arizona for producing cotton, sorghum, sugar beets, alfalfa, and wheat. Using the model developed above, the energy requirements of alternative technologies will be evaluated, both from the standpoint of total energy and energy derived from each particular energy source (electricity, diesel, natural gas, etc.). Identification of alternative technologies is not a straight forward process, however several general areas show promise for energy savings. Fertilizer substitutions. Alternate irrigation techniques. Changes in cultural practices. Improvements in machinery maintenance. The project will evaluate changes in each of these areas.

PROGRESS: The energy used for irrigation using various surface, sprinkler, and drip irrigation systems was analyzed to determine the most efficient methods and the conditions under which the systems are most energy efficient. Surface methods were found most efficient where water management is very good. The technical and economic feasibility of using solar energy to drive irrigation pumps was analyzed and most effective methods for utilizing a solar powered pumping system were studied. Changes in irrigation and pumping practices might include lowering peak demand and matching demand with solar energy input throughout the year, use of water storage, daytime only pumping and use of variable speed pumps. Use of solar energy will be economical if fuel prices rise sufficiently, solar components are developed and their cost reduced and solar plant is fully utilized.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Arizona

1.0020,

SOLAR ENERGY UTILIZATION IN DAIRIES

F. Wiersma, University of Arizona, Agricultural Experiment Station, Dept. of Soils Water & Engineering, *Tucson, Arizona* 85721 (7092-20401-12A(1))

OBJECTIVE: Develop design criteria for use of solar energy for heating and cooling needs in dairy facilities in various climatic regions, develop a computer simulation model for evaluation of solar energy systems for dairies, and determine economic feasibility of use of solar energy systems for dairies.

APPROACH: Basic design parameters developed by ARS-USDA at Beltsville, MD, for use of solar energy in milking phase of dairy production, will be adapted to various climatic conditions, with emphasis on desert climates of Southwest. A computer simulation model will be developed to facilitate evaluation, including economic feasibility of solar energy systems in dairies. Plans will be prepared for use of solar energy in a research dairy in Arizona for verification of studies.

PROGRESS: In a cooperative effort of agriculturalists and engineers, the application of solar energy to meet the heating needs of dairies is being studied. Energy related design criteria for dairy facilities are being determined. A small solar collecting system to meet part of the needs for heating water in the milking parlor for a 130-cow dairy is installed to provide data for design criteria for a solar water heating system for dairies. The work is coordinated with study on solar heating for dairies at Beltsville, MD.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Alabama - North Mississippi Area

1.0021,

RESIDENTIAL ENVIRONMENTAL CONTROL UTILIZING A COMBINED SOLAR COLLECTOR GREENHOUSE

C.N. Hodges, University of Arizona, Graduate School, *Tucson, Arizona* 85721 (7099-20690-010-A2)

OBJECTIVE: Evaluate the economic and environmental desirability of developing greenhouses as part of residential buildings to reduce the requirement for fossil fuels, to enhance the home environment, and to add food production potential.

APPROACH: Modify existing greenhouse/office structure and instrument to monitor the environment, including amount of solar energy available to the greenhouse and the percentage of this that can be utilized within the connecting office (residence). Compare plant growth and resulting environment with those in an unattached greenhouse. Evaluate use of liquid foam between layers of plastic greenhouse covers for nighttime insulation, interaction between residential environment and optimum plant growing conditions in a combined greenhouse and residence, and evaluate the potential of combining greenhouses and residences.

PROGRESS: Vegetables were grown in the greenhouse-office complex under summer cooling conditions. Two models of greenhouse cooling were compared, a single-stage evaporative cooling system and a two-stage system. The two-stage system maintained greenhouse air temperatures about 5 F lower than the direct (single-stage) cooling system. During the winter the greenhouse/office unit has been warmed during the day by the heat energy entering the unit, as the greenhouse structure during daylight hours is itself acting as a solar collector. The 'Clear-View' solar collector, which forms the south wall of the greenhouse, is in operation and will separately collect solar thermal energy during daylight hours for storage in a rockbed. The stored heat is subsequently used in the heating of the greenhouse/office or residential spaces during the nighttime and early morning hours. The production of vegetables continues to be over the estimated yield, except for October. Vegetables are being produced on an average of over 1.7 pounds per day.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0022,

SYSTEMS AND REQUIREMENTS FOR MODIFIED ENVIRONMENTS IN POULTRY PRODUCTION

G.S. Nelson, University of Arkansas, Fayetteville Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Fayetteville, Arkansas* 72701 (ARK00704)

OBJECTIVE: Evaluate effects of combinations of environmental variables on poultry. Determine suitable environmental conditions for commercial poultry flocks. Develop efficient systems to maintain required environmental conditions for poultry.

APPROACH: Environmental factors, including temperature, humidity, ventilation, light, air contaminants, bird density, and litter, will be studied in closely controlled environmental chambers. Response will be evaluated by physiological and production measurements. Engineering problems of providing suitable environments in commercial sized units will be studied by mathematical and physical models where practical. Full-scale production units will be used to evaluate new or revised environmental control methods and systems. Emphasis will be on engineering, production and economic factors.

PROGRESS: Design and construction of a 7000 bird capacity broiler house has been completed. Energy saving features of this house include a self-storing, folding, insulated partition for half-house brooding. 2167 square foot solar collector system to supply heated air to heat this house has been designed. Construction of the collector system is in progress. The Title V Ozarks Regional Commission gave a grant to the Arkansas Agricultural Experiment Station to build and test a 7,500 capacity solar-heated broiler house. The house will be ready for the first chick placement in early 1977. The economist's task has been to provide a list of economic data that need to be recorded. These include value of the chicks when placed in the house, value of feed fed, loading dock, value of the grown broilers prior to slaughter, the dollar amount that a commercial grower would receive from the integrated company under that company's normal contract. A second task is to develop a methodology for using weather data tapes to make profit and return-on-investment estimates for different yearly weather conditions.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Arkansas

1.0023,

ENERGY CONSERVATION ALTERNATIVES FOR ARKANSAS RURAL RESIDENCES

T.R. Rokeby, University of Arkansas, Fayetteville Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Fayetteville, Arkansas* 72701 (ARK00841)

OBJECTIVE: Develop, evaluate and optimize methods of energy conservation for Arkansas residences. Evaluate and develop systems for use and control of alternative energy sources, principally solar, for heating rural residences.

APPROACH: Apply a dynamic mathematical model of typical Arkansas residences to predict thermal performance, including energy comsumption. Use the model to select optimum energy conservation practices for Arkansas residences. Verify predicted performance by observation of actual residences incorporating such conservation methods. Apply the model to predict performance of solar heating systems for Arkansas residences and validate by observation of two or more solar heated residences to constructed. Determine fuel and power consumption, construction and operating costs of solar heated residences and compare with conventional residences.

PROGRESS: A solar collector of the hot air type suitable for residential heating has been designed. Equipment to test this unit has been selected and is being assembled. Planning of a solar heated residence for an experiment station employee is under way. This planning involves Extension as well as Experiment Station personnel.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Arkansas

1.0024,

BROODING CHICKS WITH SOLAR ENERGY

T.R. Rokeby, University of Arkansas, Fayetteville Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Fayetteville, Arkansas* 72701 (ARK00923)

OBJECTIVE: Develop systems and operating methods for using solar heat to brood chickens, with emphasis on retrofitting existing buildings. Develop systems and methods for conserving heat energy in brooding chickens. Evaluate the physical and biological performance of the proposed conservation measures and solar heating systems. Determine the economic feasibility of using solar heating and conservation measures for brooding chickens.

APPROACH: Weather and environmental conditions and energy flows in a solar heated commercial broiler house will be studied. Biological performance, including mortality, weights and feed conversion will be monitored. Economic factors, including returns from a standard grower contract, will be determined. Resulting data will be used as a base for improved designs, economic analyses and computer modeling of energy management systems.

SUPPORTED BY Arkansas State Government

1.0025,

SOLAR HEATED SEPTIC TANKS FOR DEAD POULTRY DISPOSAL

W.K. Warnock, University of Arkansas, Fayetteville Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Fayetteville, Arkansas* 72701 (ARK00935)

OBJECTIVE: Demonstrate the use of septic tank-filter field systems for poultry disposal. Demostrate the effects of heating and agitation on the efficiency of septic tanks for poultry disposal. Investigate overall energy efficiency of solar heated septic tanks. Investigate the economic incentives for using heated septic tank-filter field systems for dead poultry disposal.

APPROACH: Two solar heated septic tank systems with one control system will be located on the University of Arkansas Main Experiment Station Fayetteville, Arkansas. Water samples will be collected monthly from each septic tank's effluent and from two well points installed below each filter field. Water samples will be analyzed for concentration of total solids, suspended solids, volatile solids, etc. Two solar collector systems will maintain optimum biological temperatures in the septic tanks. The relative economics of heated septic tank systems for dead chicken disposal will be determined by comparing the construction and operating costs of the research units with other disposal methods.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Arkansas

1.0026,

RESEARCH ON THE APPLICATION OF SOLAR ENERGY TO THE FOOD DRYING INDUSTRY

T.M. Lukes, California State University & Colleges, California Polytechnic State University, School of Agriculture & Natural Resources, Dept. of Food Industries, *San Luis Obispo, California* 93407

Description: The task is to study the economic and marketing feasibility of using solar energy in the food drying industry. As background, the following studies were made: literature search; socio-legal implications; energy now used, and projected use in 1985 and 2000; economic implications; drying at temperatures lower than the industry presently uses. As a result of computer modeling it was decided to design a solar energy system using air as the medium, without heat storage. Hot air from the collector will be raised to operating temperatures with gas heat (or steam coils). No more than 25% of the energy needed for dehydration can be obtained economically from the solar collector. Various fruits and vegetables will then be dried; measurements and analyses will then show if the system is feasible.

SUPPORTED BY U.S. National Science Foundation, Div. of Advanced Productivity Research & Technology

1.0027,

APPLICATION OF SOLAR ENERGY TO INDUSTRIAL DRYING

E.J. Carnegie, California State University & Colleges, California Polytechnic State University, School of Engineering & Technology, Dept. of Agricultural Engineering, *San Luis Obispo, California* 93407 (E(40-1)-5123)

Under the auspices of ERDA, California Polytechnic State University in conjunction with TRW and Lamanuzzi and Pantaleo (L and P) has designed a solar system to dehydrate food as an appropriate industrial process. This project is divided into three phases. It was the purpose of this project in Phase I to establish viability of a solar collector, heat storage and heat recovery system capable of supplying a significant portion of the heat required by a single tunnel of the L and P dehydration facility in Fresno, California. The solar system now under construction in Phase II is an air collector using 21,000 sq. ft. and 13,000 cu. ft. of rock storage.

SUPPORTED BY U.S. Dept. of Energy

1.0028,

APPLICATION OF SOLAR ENERGY TO A TRUCK AND TUNNEL DEHYDRATOR: INDUSTRIAL DEHYDRATION

E.J. Carnegie, California State University & Colleges, California Polytechnic State University, School of Engineering & Technology, Dept. of Agricultureal Engineering, *San Luis Obispo, California* 93407 (E(40-1)-5123)

It is the purpose of this project to establish the viability of solar energy as a reliable and practical source of heat in industrial dehydration processes. The project is divided into three phases: namely, the analysis and design, construction, and evaluation of a complete solar dehydration facility operating under normal commercial conditions. This system, now being built, will operate a commercial truck-and-tunnel dehydrator operating near Fresno, California, where raisins, fruits and vegetables are being dehydrated. This project has been subcontracted.

SUPPORTED BY U.S. Dept. of Energy

1.0029,

MONITORING OF SUNCATCHER PASSIVE-SOLAR HOUSE AND MODEL DEVELOPMENT COMPUTER

B.T. Maeda, Davis Alternative Tech. Associates, Earth Integral of Liv Sys, *Davis, California* 95616

Electronic monitoring of solar system components in a house is planned. Components include thermal storage (water and concrete), shutters, and sun catcher collector (roof configuration). The system is passive. Also development of a math model for predicting performance of components in different climates is included.

SUPPORTED BY U.S. Dept. of Energy

1.0030,

INTEGRATED SINGLE FAMILY SOLAR HOT WATER FLOW THROUGH SYSTEM USING TWO STORAGE TANKS, CASCADE CONTROL SYSTEM (ABBREV)

T. Honikman, Elcam Inc., *Santa Barbara, California* 93111 (0AS8-32245)

Development of an integrated single family solar hot water flow through system using two storage tanks with a cascade control system and a collector dump valve for freeze protection.

Elcam, Inc., will design, develop and deliver two identical single family solar assisted hot water systems to two sites. The hot water systems use flat-plate, liquid heating collectors with a non-selective coating and a single glazing. Cascade control system will be used. The two sites for installation are Phoenix, AZ, and San Diego, CA. Marshall Space Flight Center will monitor equipment performance. (DOE/CS-0010)

SUPPORTED BY U.S. Dept. of Energy, Office of Conservation & Solar Applications, Div. of Solar Applications

1.0031,

SOLAR HEATING AND COOLING DEMONSTRATION - CAMARILLO, CALIFORNIA

Unknown, Leisure Technology of California Inc., *Camarillo, California* 93010

The project involves the application of a solar domestic hot water preheating system to a 1,200 square foot single family attached dwelling. A single solar collector panel is mounted at the proper orientation and tilt on the dwelling's sloping south-facing roof. The collector is connected to a storage tank located in the basement of the house.

SOLAR APPLICATION: Hot water.

COLLECTOR: 18 square feet liquid-cooled flat-plate manufactured by Raypak. The black painted absorber consists of an aluminum surface with copper bonded tubes.

STORAGE: 40 gallons of water within an insulated storage tank located in the basement.

DISTRIBUTION: Domestic water is preheated by the collector and stored in the 40 gallon storage tank. The preheated water passes through a conventional water heat where an energy boost may be supplied before being distributed to the house.

AUXILIARY ENERGY SYSTEM: Electric water heat. 30 gallon electric water heater provides total or partial heating as dictated by temperatures from the preheat tank.

DOMESTIC HOT WATER SYSTEM: Refer to collector, storage, and distribution for details.

COOLING: Not applicable.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0032,

RED TAIL DISEASE IN CRAYFISH

C.J. Poulos, Monterey Bay Research Inst., Dept. of Microbiology, *2700 Chanticleer Ave., Santa Cruz, California* 95065 (NBHR-0003)

OBJECTIVE: Identify and treat an outbreak of 'Red Tail disease' in crayfish in a close system culture hatchery.

METHOD: Isolated all infected crayfish. It was noted the disease appears to affect more of the Pacifasticus leniusculus species and only slightly in the Procambarus clarkii species. The crayfish appear to be active in spite of infection until the later stages, the death occurs within a few hours.

Disease onset is noted with a pale pink coloration of the tails becoming darker and brighter red as the disease progresses. Internally the present of pink to opaque fluid in the abdominal cavity, the heptopancrease pale, swollen and some showed petechiae in the musculature. Bacterological studies showed the following: gas and acid produced in tubes of a basal medium (inoculated from a pure culture) indicative of the genus Aeromona.

Disease occured in the hatchery after a solar heating system was installed raising the water temperature to 6 degree F. from the prior 54 degrees F. Antibiotic sensitivity test were performed, and treatment of nitrofuran at 8 ppm, four times daily for one week was started. Treatment was successful.

Studies into mode of transmission, source and reservoir of infection continues.

SUPPORTED BY Monterey Bay Hydroculture Farms

1.0033,

REVIEW AND EVALUATION OF DOE'S SOLAR ENERGY PROGRAM

J.G. Witwer, S R I International, *300 Ravenswood Ave., Menlo Park, California* 94025

SRI is working with the General Advisory Committee of DOE to perform a comprehensive evaluation of DOE's solar energy program. This evaluation will play a major role in shaping the future national R and program for the principle solar technologies--heating and cooling of buildings, industrial and agricultural process heat, wind, ocean thermal energy conversion, photovoltaics, thermal power, and biomass. This evaluation will be based upon several key factors including potential energy contribution, net energy, economic attractiveness, environmental considerations, and international market opportunities.

SUPPORTED BY U.S. Dept. of Energy

1.0034,

SOLAR HEATING & COOLING DEMONSTRATION - SANTA CLARA, CALIFORNIA

Unknown, Santa Clara City Government, *1500 Warburton Ave., Santa Clara, California* 95050

The project consists of five, single family detached dwellings each combined with a solar heating and domestic hot water preheating system. The two-story house design has a total of 2,000 square feet of heated floor area. The solar energy system will be owned by the public utility company and leased to the individual homeowner.

SOLAR APPLICATION: Heating and Hot water.

COLLECTOR: Liquid-cooled flat-plate manufactured by Solar King, Inc. The size of the collector varies from 160 to 288 square feet.

STORAGE: 1,500 gallons of water within an insulated steel tank located in the basement of each dwelling.

DISTRIBUTION: Forced air. Hot water from storage is pumped through a heating coil in the primary supply duct. A fan circulates air through the coil. The warmed air is then distributed by ducts to living spaces.

AUXILIARY ENERGY SYSTEM: Gas-fired furnace. The furnace provides total or supplemental heating as required.

DOMESTIC HOT WATER SYSTEM: Hot water from storage circulating through a copper immersion coil preheats the water in the conventional water heater's 70 gallon tank.

COOLING: Natural ventilation.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0035,

SOLAR HEATING AND COOLING DEMONSTRATION - SELMA, CALIFORNIA

Unknown, Self Help Enterprises, *Selma, California* 93662

The project consists of five one story single family dwellings each with 1,152 square feet of heated/cooled floor area. Water filled black plastic bags located within the flat roof structure provide passive solar energy collection and storage. The solar system supplies both heating and cooling. Exposure of the bags to solar radiation is controlled by movable insulated panels.

SOLAR APPLICATION: HEATING AND COOLING

COLLECTOR: 960 square feet solar pond utilizing the patented 'Skytherm' process. Movable insulated panels regulate solar exposure of the pond (water bags).

STORAGE: 660 cubic feet of water in black plastic bags located within the roof structure serves as the collector and storage element.

DISTRIBUTION: The water bags radiate captured heat through the corrugated steel roof to the living space. The insulating panels protect the living space from over-heating or cooling by appropriate covering or exposing of the bags.

AUXILIARY ENERGY SYSTEM: A 5,000 watt electric resistance heater system and a 4.50 ton evaporative cooler back-up the same energy system.

DOMESTIC HOT WATER SYSTEM: Domestic hot water is heated by a conventional electric water heater with the insulation panels closed.

COOLING: Water bags absorb heat from the house during the day. At night, the panels are opened and the absorbed heat is radiated to the cool night sky.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0036,

DESIGN AND DEVELOPMENT OF SINGLE FAMILY, MULTI-FAMILY, LIGHT COMMERCIAL, AND COMMERCIAL SIZE SOLAR HEATING AND COOLING SYSTEMS

G. McDonald, Signal Companies Inc., AiResearch Manufacturing, *2525 W. 190th St., Torrance, California* 90509 (NAS8-32091)

AiResearch will design, develop and deliver four sizes of various solar heating and cooling systems for equipment monitoring by Marshall Space Flight Center (NASA). These systems are: (1) single family heating, cooling and hot water--(a) single loop, solar assisted heat pump and domestic hot water, (b) Rankine driven turbo compressor heat pump and cooling tower, (c) flat plate collectors and storage tanks, (d) 3-ton cooling capacity, 80,000 Btu/hr heating capacity, and (e) site locations--Novato, CA, Allaire State Park, NJ, Harrisonburg, VA, and Lawrenceburg, TN; (2) light commercial heating, cooling and hot water--(a) same system characteristics as 1, (b) 25-ton capacity, 80,000 Btu/hr heating capacity, and (c) site locations--St. Louis, MO and Los Angeles, CA (general area); and (3) commercial heating, cooling and hot water--(a) same system characteristics as 1 above, (b) 75-ton cooling capacity, 2,000,000 Btu/hr heating capacity, and (c) site locations--Clear Lake (Houston), TX and Las Vegas, NV. (DOE/CS-0010)

SUPPORTED BY U.S. Dept. of Energy, Office of Conservation & Solar Applications, Div. of Solar Applications

1.0037,

SOLAR HEATING AND COOLING DEMONSTRATION - LOS ANGELES, CALIFORNIA

Unknown, Southern California Gas Co., *810 S. Flower St., P.O. Box 3249, Los Angeles, California* 90017

A solar-assisted gas water heater was retrofitted into two El Toro, California apartment buildings. Cost, installation, and performance data will be collected. The data will be used for technical and financial evaluations of the project. The operating costs for systems serving multiple unit buildings are more visible than those for systems serving single family homes. At the same time, multiple unit capital investments are easier to arrange. Cost data from projects such as this will be particularly valuable, helping investors to determine the favorable and unfavorable aspects of investment in multiple unit systems.

This project was funded by the National Science Foundation. ERDA maintains technical cognizance. The expected operational date was August 1975.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0038,

OPTIMIZING WET FRACTIONATION OF FORAGES FOR IMPROVED FEED PRODUCTS

R.H. Edwards, U.S. Dept. of Agriculture, Agricultural Research Service, Western Regional Research Center, Feedstuffs Research, *800 Buchanan St., Albany, California* 94710 (5102-20520-016)

OBJECTIVE: Prepare improved animal feeds from field crops, especially alfalfa, with emphasis on reducing energy requirements and costs, and increasing nutritional value.

APPROACH: Wet processing of forages will be developed further by: Optimizing LPC drying conditions to maximize nutrient availability; preparing LPC-encapsulated fats for use in high energy feeds; eliminating pigmenting xanthophylls in LPC for high-level feeding; reducing energy requirement via recovering process waste heat, optimizing grinding and pressing, using solar energy (wilting) for preliminary moisture removal, and adaptations for 'on-the-feedlot' processing, including fresh feeding and ensiling press cake; and using leaf-enriched raw material, and using green crops in addition to alfalfa, to extend the operating season and region. In collaboration with a commercial alfalfa dehydrator, and with financial assistance from the Department of Energy, the LPC process will be expanded to commercial scale; process design, operation, and product marketability will be optimized. Digestibility of hays, silage, and LPC press cake will be improved by cell disruption.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Western Regional Research Center

1.0039,

IMPROVED FRUIT AND VEGETABLE PROCESSING AND PRODUCTS

D.F. Farkas, U.S. Dept. of Agriculture, Agricultural Research Service, Western Regional Research Center, *800 Buchanan St., Albany, California* 94710 (5102-20510-010)

OBJECTIVE: Increase quality, stability and nutritive values of fruit and vegetable products via development of more efficient processing and handling methods.

APPROACH: New forms of fruits and vegetables, such as pre-cored apples, chopped lettuce, and cut asparagus, will be studied to determine factors affecting quality and nutrient retention. Systems for handling and processing such new forms will be integrated with those for mechanized harvesting and subsequent marketing. Chemical, and other, techniques will be developed for pre-processing highly perishable commodities, e.g., peaches, prior to final processing. New methods will be sought to prevent enzymatic browning with low or no use of sulfur dioxide. Effects of new processing methods on nutrients will be determined; potential food use of processing discards will also be studied.

PROGRESS: Microwaves were used to aid rapid heating of non-oil-containing fexible pouches. Taste tests showed a superior product by combining a one-minute microwave exposure with a ten-minute hold in water, at 250-260 F under pressure. Microbiological tests indicated non-uniform microwave energy distribution in 5-oz. pouches in a cylindrical pressure vessel. Further work is needed to improve energy distribution. Intermediate-moisture fruits and vegetables were prepared without artifical plasticizers. Vegetables were given lactic-acid fermentation prior to drying. Lower temperature drying methods (120-140 F), without blanching or sulfur pretreatment, were tested to demonstrate effect of energy-saving, solar- assisted drying methods on fruit and vegetable quality at intermediate moisture levels. Diced cling peaches were frozen in bulk, dehydrofrozen, or stored in refrigerated solutions containing mixtures of sucrose, citric acid, ascorbic acid, sodium benzoate, and potassium sorbate, to compare effects of these storage conditions on quality of peaches packed in individual- serving-sized plastic containers. Treatments and storage conditions to extend storage life of fresh shredded lettuce were developed. Pouches of shredded lettuce retained marketable quality 2.5 times longer at 2 C than at 10 C. Slicing with a sharp blade produced best results. Chopping, small shred size, physical damage, moisture of cellular fluids on lettuce surface, high microbial loads all reduced storage life.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Western Regional Research Center

1.0040,

REDUCING ENERGY USE IN PROCESSING FOODS, ESPECIALLY FRUITS AND VEGETABLES

W.C. Rockwell, U.S. Dept. of Agriculture, Agricultural Research Service, Western Regional Research Center, *800 Buchanan St., Albany, California* 94710 (5102-20510-016)

OBJECTIVE: Develop better systems for processing fruits, vegetables, and other foods such that energy use is cut but product safety, quality, and nutritive value are retained.

APPROACH: Examine the most energy-costly steps in food processing systems to improve their efficiency of energy use. For example, study present blanching practices for various foods, determine minimum blanching temperatures and times, and test on laboratory and pilot scale. Extend the 'double-dip' lye application procedure to all major fruit and vegetable commodities that require peeling. Evaluate membrane processing (e.g., reverse osmosis) for reducing energy use in concentrating foods to purees and pastes. Determine the feasibility of using solar energy to assist fruit and vegetable drying processes. In all cases, determine effects on product safety, quality, nutritive value, and stability. Assist in pilot-to-commercial scale up and adoption.

PROGRESS: A low-cost solar dehydrator unit was constructed wherein solar energy was the sole source for heating air. A solar collector consisting of a one-meter diameter polyethylene tube 12-24 meters long was tested. Apricots and prunes were dehydrated, using either a through-flow or partial recirculation procedure. In the latter procedure, temperature increase of 30 C over ambient was obtained. Apricots dried 38% faster than direct sun-

dried. Design calculations were begun for a small scale solar dryer using silica gel for thermal storage. Computer model of silica gel adsorption-desorption developed last year being used to size the thermal storage bed; standard methods are used to size solar air heater. Low pressure-reflux reverse osmosis proved feasible on lab-scale; pilot plant equipment is being developed. Direct osmosis for diluting molasses with water from concentrating thin sugar-beet juice is being developed to reduce energy consumption in beet sugar processing. Osmosis scheme can eliminate a significant portion of the evaporation of water required to concentrate beet juice. Aqueous freezant mixtures (15% NaCl 15% EtOh water) successfully froze a variety of vegetables. Energy savings of 20-30% possible over air freezing.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Western Regional Research Center

1.0041,
INVESTIGATIONS OF THE PROPERTIES AND PERFORMANCE OF WOOD IN USE
W.A. Dost, University of California, Berkeley Campus, Agricultural Experiment Station, *Berkeley, California* 94720 (CA-F#-FPL-2876)
OBJECTIVE: Develop data with which to explain the performance of wood to its users.
APPROACH: Wood specimens and constructions will be examined with techniques and under conditions appropriate to the properties being evaluated. The data will be used to estimate or interpret the conditions at the time of manufacture or the performance of the specimen in use and to make recommendations for corrective measures.
PROGRESS: Project activities focused primarily on drying of lumber. These were usually conducted in cooperation with industry on specific applied problems. The drying of young-growth ponderosa pine studs under a restraining load of 200 lbs/ft was found to be effective in reducing warp. Three techniques were examined in drying: (1) air-drying; (2) conventional kiln schedules; and t3) high temperature kiln schedule. A 20% reduction in warp was achieved using restriant with conventional kiln schedule. Other work in drying included: (1) investigation of drying redwood cross-sections by conventional and hihg-temperature kiln scheuldes; and t2) development of a degrade severity index for kiln drying schedules. Interest in solar dyring of lumber has increased with rising energy costs. Work with solar energy was started by construction of small-scale solar kiln of flatplate collector design. The kiln is currently being evaluated for drying charactertisics.
SUPPORTED BY California State Government

1.0042,
RESONANCE STUDIES IN BIOPHYSICS
Unknown, University of California, Berkeley Campus, Lawrence Berkeley Lab., *Berkeley, California* 94720
DESCRIPTION: Molecular biophysics of bioenergetic oxidation-reduction processes in photosynthesis and in the active sites of metalloenzymes. These studies are centered about the application of low spectroscopy to determinations of the electronic configurations of biologically important molecules or portions of molecules. Specifically, these biophysical resonance techniques have been applied to the study of primary reaction in photosynthesis, a study of the possible receptors for phototactic behavior in bacteria, a study of the mechanism of electron transfer in iron-sulfur proteins (ferredoxins), and the elucidation of electron-transport complexes in photosynthesis and in the process of oxidative phosphorylation. This research also draws on experimental methods of improving the sensitivity and applicability of resonance spectroscopies (electron spin resonance and Mossbauer spectroscopy), the utilization of new physical techniques in biological application, and the use of theoretical and computational techniques form quantum physics in a biological context. By these methods it is hoped to discover or find photochemistry involved in both green plant and bacterial photosynthesis, understand the oxidation-reduction properties of the iron-sulfur proteins in terms of structure, find a link between photochemically produced electron spin resonance signals and the phototactic behavior bacteria, and continue to study possible applications of primary photosynthetic chemistry to the conversion of solar energy into electricity.
ADDENDA: Estimated calendar year funding reported as 1975 $30,000.
SUPPORTED BY U.S. Dept. of Energy, Div. of Biomedical & Environmental Research

1.0043,
AN INTEGRATED SYSTEM FOR CONVERSION OF SOLAR ENERGY USING WASTE-GROWTH FILAMENTOUS BLUE-GREEN ALGAE BIOMASS
W.J. Oswald, University of California, Berkeley Campus, School of Engineering, Dept. of Civil Engin, *Berkeley, California* 94720 (E(04-3)-34)
Microscopic algae grown in lagoons are uneconomic for energy purposes because no easy means for harvesting has been found. Filamentous algae are larger and can be collected with a screening device called a microstrainer. This project will demonstrate the growth of filamentous algae in ponds. Species will be controlled by various means such as recycling of part of the desired organisms, control of pond conditions, and adjustments of the growth medium. A total system will be devised using municipal sewage for its nutrient value and using carbon dioxide from a combustion power plant to overcome carbon limitations. Digestion of the harvested algae to methane will be studied. Process development will be performed on each step, and scale-up and economics of a large system will be analyzed. (ERDA 76-137)
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0044,
SOLAR ENERGY CONVERSION WITH HYDROGEN PRODUCING ALGAE
W.J. Oswald, University of California, Berkeley Campus, School of Engineering, Dept. of Civil Engin, *Berkeley, California* 94720 (E(04-3)-34)
Photosynthesis is an efficient process for the conversion of solar energy into chemical energy. Many algae are capable of photosynthesis, oxygen evolution from water coupled to CO-2 reduction, and hydrogen production. This proposal will determine the feasibility of the use of one type of algae, the nitrogen-fixing heterocystous blue-green algae, in solar energy convertors which produce hydrogen by the biophotolysis of water. Oxygen inhibits hydrogen-evolving enzymes and therefore photosynthetic oxygen production and hydrogen evolution do not occur simultaneously in the same cell; these two processes must be separated. Heterocystous blue-green algae are filamentous types containing specialized cells, the heterocysts, where the hydrogen-evolving enzymes are localized and protected from oxygen. The experiments to be performed are to prove the basic potential of these algae in biophotolysis by demonstrating a sustained conversion of sunlight energy into hydrogen energy. Small-scale convertors will be designed and used under specified conditions simulating possible operating situations. Research will include problems of algal physiology, selections of suitable strains, and engineering designs of the bioconverters. The economics of solar energy conversion with algae will be analyzed. (ERDA 76-137)
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0045,
ENERGY IN WESTERN AGRICULTURE - REQUIREMENTS, ADJUSTMENTS, AND ALTERNATIVES
W.J. Chancellor, University of California, Davis Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Davis, California* 95616 (CA-D#-AER-2975-RR)
OBJECTIVE: Estimate current patterns and amounts of energy inputs currently utilized in Western agriculture. Assess contributions of, and prospects for, alternative technologies and policies for dealing with changes in energy availability.
APPROACH: Field and interview investigations of details of energy use for inputs, production, transport, processing and distribution of key agricultural commodities. Investigation of energy use for alternative technologies at each of the above stages.
PROGRESS: Studies on detailed energy requirements for wheat production were completed and similar studies for sugarbeet production and processing instituted. Sugarbeets in California require more energy annually than any other single crop. The major requirement is in the processing of the beets. The 23 percent of the process energy required for drying (2 percent of California's agricultural energy requirement) represents a potential area for substitution of renewable energy sources (such as solar or crop residues) for natural gas -- currently the main energy source for sugarbeet processing and fertilizer production. Studies on the feasibility of a month-by-month monitoring and requirement projecting system for California's agricultural energy flows is currently underway.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, California

1.0046,
DRYING ANIMAL WASTES WITH SOLAR ENERGY
B. Horsfield, University of California, Davis Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Davis, California* 95616 (7090-12012-008-A)
OBJECTIVE: Determine the feasibility of drying animal wastes with solar energy in order to eliminate use of fossil fuel for waste drying, reduce fuel used for transporting waste, and to improve the utilization of waste as plant nutrients.
APPROACH: A manure dryer capable of drying livestock wastes with solar heat, with a year's manure storage capability, will be designed and built. The unit will be used to process waste from a swine production unit. Performance of the unit will be evaluated with respect to drying efficiency and rate, and efficiency of manure nutrient maintenance. The unit will be evaluated for economic feasibility.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Alabama - North Mississippi Area

1.0047,
ON-SITE STABILIZATION OF DAIRY AND BEEF CATTLE WASTES
A.C. Chang, University of California, Riverside Campus, Agricultural Experiment Station, Dept. of Soil Science & Agric Engin, *Riverside, California* 92502 (CA-R#-SSE-2774-H)
OBJECTIVE: Investigate the feasibility of on-site decomposition of animal wastes, determine the movement of pollutants and simulate the management system mathematically.
APPROACH: Survey the present waste management practices; laboratory and field studies to determine the environmental effects on the rate and degree of waste stabilization; determination of nutrients movement and transport of heavy metal ions during the process; construction and verification of the mathematical model; and estimation of management alternative.
PROGRESS: Freshly collected animal wastes from dairy and beef cattle feedlots were collected and classified by particle sizes using wet sieving technique. Results indicated a particle size distribution that with majority of the material rest upon two extremes (size greater than 18 mesh or size less than 270 mesh). As particle size became finer, nutrient (N and P) concentrations increased significantly. This nutrient enrichment induced by particle size classification would undoubtedly increase the potential of its recovery. Experiments are initiated to study techniques of harvesting them from a slurry AND TO SEEK MEANS OF FURTHER SEPARATING THEM BY THEIR PHYSICAL OR ELECTRICAL PROPERTIES. Coarse fraction consisted of mostly fibrous material. Plans are underway to study the solar drying & heat energy recovery from this fraction of the wastes. Soil samples from unpaved feedlots were collected at 6' intervals & packed into 3' diamter (4 ft) columns based on the field measured soil bulk density of the profile. These colums were then leached with pore volumes of water. Leachates from each leaching cycles were collected & analyzed to determine the leaching potential of feedlot manure contaminated soils. Columns were then sectioned at 6' intervals to determine the physical & chemical changes of soils.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, California

1.0048,
BIOCONVERSION OF SOLAR ENERGY AND PRODUCTION OF HYDROGEN BY PHOTOLYSIS
M.D. Kamen, University of California, San Diego Campus, Graduate School, Dept. of Chemistry, *P.O. Box 109, La Jolla, California* 92037
This award is a continuation of NSF grant GI-36249. Research for the coming year will deal primarily with maximizing the efficiency of the hydrogen producing system. This involves extending the research on the hydrogenase stabilization and the efficient coupling with the photosynthetic apparatus. Techniques for further stabilization of the photosynthetic system will be investigated and continued studies on comparative photosynthetic systems will be made. It is also

planned to continue research using model systems for the investigation of enzyme immobilization techniques. An additional area of research will be the use of affinity chromatography for the purification of the integral enzymes in the photosynthetic-hydrogenase system as well as the auxiliary enzymes for energy storage.
SUPPORTED BY U.S. National Science Foundation, Div. of Advanced Energy & Resources Research & Technology

1.0049,
ASSESSMENT OF A SINGLE FAMILY RESIDENCE SOLAR HEATING SYSTEM IN A SUBURBAN DEVELOPMENT SETTING
J.D. Phillips, Colorado Springs Dept. of Public Utilities, *P.O. Box 1103, Colorado Springs, Colorado* 80901
DESCRIPTION: The city of Colorado Springs Utility Department in conjunction with the Phoenix Corporation has received a grant from the National Science Foundation's Research Applied to National Needs Program which provides support for instrumentation and data-gathering on a solar heating system installed in a residence erected by the Phoenix Corporation in a residential neighborhood in Colorado Springs. The City and Phoenix also plan, while the technical test program is underway for two years, to collect detailed data on the economic, legal and social acceptance considerations related to the operation of a solar-heated house in a suburban residential setting. This proposal to the National Science Foundation's Intergovernmental Science Program would provide funds so that the City and Phoenix could utilize function experts to assist in the formulation of the data-gathering in the three supplementary areas and in the analysis and improvement of the first annual and the final project reports.
ADDENDA: Estimated calendar year funding reported as 1975 $60,000.
SUPPORTED BY U.S. National Science Foundation, Unspecified Unit

1.0050,
DESIGN OF SOCIAL, ECONOMIC AND LEGAL DATA-GATHERING RELATIVE TO A SOLAR-HEATED HOUSE
J.D. Phillips, Colorado Springs Dept. of Public Utilities, *P.O. Box 1103, Colorado Springs, Colorado* 80901
The City of Colorado Springs Utility Department in conjunction with the Phoenix Corporation has received a grant from the National Science Foundation's Research Applied to National Needs Program which provides support for instrumentation and data-gathering on a solar heating system installed in a residence erected by the Phoenix Corporation in a residential neighborhood in Colorado Springs. The City and Phoenix also plan, while the technical test program is underway for two years, to collect detailed data on the economic, legal, and social acceptance considerations related to the operation of a solar-heated house in a suburban residential setting. This proposal to the National Science Foundation's Intergovernmental Science Program would provide funds so that the City and Phoenix could utilize functional experts to assist in the formulation of the data-gathering in the three supplemetary areas and in the analysis and improvement of the first annual and the final project reports.
SUPPORTED BY U.S. National Science Foundation, Div. of Intergov. Science & Public Technology

1.0051,
ALTERNATE ENERGY SOURCES FOR AGRICULTURAL APPLICATIONS
R.W. Hansen, Colorado State University, School of Agricultural Sciences, Dept. of Agricultural Engineering, *Fort Collins, Colorado* 80523 (COL00064)
OBJECTIVE: Investigate alternate energy sources for agricultural applications. Develop and test a multiple-use solar heat collection, storage and application system for agricultural uses. Investigate applications of wind energy for agricultural energy needs. Investigate potential fuel production from agricultural waste material.
APPROACH: This project will investigate the possible applications of solar energy to grain drying, livestock building space heating, water heating for dairy use and similar applications. Wind energy will be investigated for potential agricultural applications. Organic waste materials will be investigated as a material for the biological production of fuel gases such as methane, utilizing new techniques to produce bio-gas.
SUPPORTED BY Colorado State Government

1.0052,
MULTIPLE USE SOLAR HEAT COLLECTOR & STORAGE SYSTEM FOR GRAIN DRYING
R.W. Hansen, Colorado State University, School of Engineering, Dept. of Agricultural Engineering, *Fort Collins, Colorado* 80523 (3090-20592-012-A1)
OBJECTIVE: Develop and demonstrate a prototype solar heat collector and storage system suitable for grain drying and other agricultural heating applications.
APPROACH: Design and build a prototype solar heat collector and storage system for a batch-in-bin grain dryer. Test prototype system for drying 24 percent moisture corn. Evaluate rock bed heat storage as a method of increasing drying potential of night air. Analyze performance of solar system for alternate uses such as livestock shelter and dairy water heating and develop design data for a multiple use system.
PROGRESS: Construction was completed of a prototype solar drying system including a solar collector and a bin of dry grain as alternative sources of drying air. Since no wet grain was available, performance was verified with wet alfalfa. A warm-air solar collector was coupled to an air-to-water heat exchanger for water heating at 30 water temperature rise. The system operates at approximately 20 gal per hour during peak radiation with a daily capacity of about 100 gal. During the 1976 harvest season a solar collector with a rock storage was tested. Two successful corn-drying tests were conducted, one initiated on Oct. 26 using 3 cfm/bu. and the other initiated Nov. 15 using 2cfm/bu. In both a temperature rise of 15 F was achieved in the collector and temperatures adequate for drying were sustained through the night by the associated rock storage.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Kansas - Nebraska Area

1.0053,
EVALUATION OF HIGH QUALITY FORAGE PRODUCED FROM SOLAR ENERGY DRYING SYSTEMS
R.W. Hansen, Colorado State University, School of Engineering, Dept. of Agricultural Engineering, *Fort Collins, Colorado* 80523 (7099-20190-011-A)
OBJECTIVE: Determine the feasibility of using solar energy to dry forage to produce a high quality feed additive.
APPROACH: Three types of forage products, whole alfalfa, alfalfa tops and grass clippings will be processed by field curing conventional high temperature dehydration and solar dehydration to produce nine and end products. These will be evaluated to determine the effect of the treatments on the various caretnoids and xanthophylls. Feeding trials will be conducted to determine the growth response due to the different drying treatments.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0054,
SOLAR HEATING OF GREENHOUSES COMBINED WITH SPACE HEATED BUILDINGS
C.C. Smith, Colorado State University, School of Engineering, Dept. of Civil Engineering, *Fort Collins, Colorado* 80523 (7093-20691-013-A(2))
OBJECTIVE: Develop, test, and demonstrate solar heating of an operational greenhouse combined with a space-heated building.
APPROACH: Design a double-layer glass greenhouse, heat storage, and solar collectors to provide an efficient integrated arrangement of these three solar components with an existing building so that solar heat collected by the greenhouse and collectors will supply about 75 percent of the heating requirements of both the building and greenhouse in Colorado. The building has 800 ft , the greenhouse will have a floor area of 800 ft and the collector will be about 700 ft in area. The components will be constructed and the entire system will be instrumented for tests during a winter heating season.
PROGRESS: A greenhouse combination with a wood frame residential-style building has been designed and operated at CSU since December 1976, using solar energy as the prime source of heating. Solar collectors, in addition to the greenhouse heat, were used during solar periods which is then passed through a pebble bed. Solar heat is thus stored for nighttime and for cloudy weather. In addition to solar space heating, the solar system heats water through a heat exchanger which is used to heat the greenhouse growing medium. Solar heated water is stored in tanks and is circulated through soil heated pipes. Also, water is solar heated which is used to irrigate plants in the greenhouse. The combined heating functions offer two performance advantages. The higher growing medium temperature allows the space temperature to be reduced in the greenhouse at night while maintaining plant production. This reduces heat loss from the greenhouse with a resulting net savings in energy. Secondly, the soil and irrigation heating loads are at lower temperatures, thus is the space heating load, with a subsequent improvement in solar collection efficiency. The solar space heating capacity has been in operation since December 1976. The soil and irrigation heating functions were added in January 1978.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0055,
DEVELOPMENT AND DEMONSTRATION OF SOLAR PROCESS DRYING OF POTATO PRODUCTS
C.C. Smith, Colorado State University, School of Engineering, Dept. of Civil Engin, *Fort Collins, Colorado* 80523 (7091-20510-007-A)
OBJECTIVE: Design solar dryer for potato products; fabricate and operate prototype model; demonstrate prototype under process drying conditions and determine energy efficiency, production efficiency, overall quality of products.
APPROACH: The solar food process dryer will be designed for optimal cost-effectiveness in terms of energy efficiency, production output, and overall product quality. Secondly, a prototype potato flake and starch powder dryer will be fabricated and operated at performance in terms of energy savings, process production output, and product quality will be determined.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Florida - Antilles Area

1.0056,
SOLAR HEATING & COOLING DEMONSTRATION - FORT COLLINS, COLORADO
Unknown, Eco Era Inc., *Fort Collins, Colorado*
The project is a 1,760 square foot two story single family residence incorporating a solar heating and domestic hot water preheating system. The building utilized wood frame construction with concrete foundation and wood shingled exterior walls. Added wall and roof insulation, smaller window area, and insulated shutters reduce the dwelling's energy requirement and improve the solar system's performance. The solar collectors are integrated with the roof structure and the storage bin is located in the unfinished basement.
SOLAR APPLICATION: HEATING AND COOLING AND HOT WATER COLLECTOR: 312 square foot air-cooled flat-plate manufactured by Solaron Corporation.
STORAGE: 394 cubic feet of one and one-half inch diameter rock within a 7 feet 6 inches x 7 feet 6 inches x 7 feet 10 inches storage bin located in the basement.
DISTRIBUTION: Forced air. Heated air from the collectors passes directly into the living spaces of the storage bin, or is vented to the outside. Distribution from storage is accomplished by a blower and ducts.
AUXILIARY ENERGY SYSTEM: Electric heat pump arranged in-line with the collectors, storage, and distribution, the heat pump provides a full or partial energy boost.
DOMESTIC HOT WATER SYSTEM: Preheated by a finned coil heat exchanger located in the primary distribution duct of the central air handling unit. Storage and auxiliary heating is provided by a conventional water heater.
COOLING: Electric heat pump, natural ventilation. Cooling by air to air heat pump is not solar assisted.
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0057,

EXPERIMENTAL INVESTIGATION: TROMBE WALL PASSIVE SOLAR COLLECTION SYSTEM

R.L. Casperson, Energy Engineering Group Inc., *Idaho Springs, Colorado* 80452 (EG-77-G-04-4145)

DOE Project to investigate the thermal balances and thermal circulation in a Trombe wall passive solar collection system using an experimental test building equipped with velocity probes, thermocouples, and pyranometer. Free convection heat transfer and fluid mechanics will be studied in the wall unit using a variable gap geometry between the masonry wall and the glazing cover unit. Energy balances on the test building will be performed for varying time periods. Privately funded research has been conducted to investigate the technical and economical feasibility of auxiliary, off-peak electrical energy storage for both solar and non-solar heating systems. Study parameters included design weather scenarios, annual electric rate increases, building space heating loads, solar storage capacity, utility rate structure, auxiliary (non-solar) storage capacity, load control strategy, solar collector type, solar collector area, collector thermal performance and costs. Privately funded research has been performed on the feasibility of wind powered electric generation plants for single residences and clusters of residences.

SUPPORTED BY U.S. Dept. of Energy, Albuquerque Operations Office

1.0058,

SOLAR HEATING & COOLING DEMONSTRATION - PUEBLO, COLORADO

Unknown, Pueblo City Government, *Pueblo, Colorado*

The project involves the application of a central solar domestic hot water heating system to five existing single family dwellings. A centrally located detached unit houses the solar collectors, heat storage tank, and necessary pumps and valves. The unit is connected by insulated pipes to the domestic hot water heaters of the five houses. Chicken wire covers the glass collection surfaces for protection from vandalism.

SOLAR APPLICATION: HEATING AND HOT WATER

COLLECTOR: 144 square feet liquid-cooled flat-plate manufactured by Raypak Inc. The system employs an automatic drain down for freeze protection. One-half the collector array is fitted for maximum summer efficiency while the other half is fitted for maximum winter efficiency.

STORAGE: 350 gallons of water stored within a glass liquid steel tank. The water circulated through the collectors is pumped to storage and then to the dwellings for distribution and possibly an energy boost.

DISTRIBUTION: Underground insulated pipes connect the central collection and storage unit to the conventional water heaters located in each house.

AUXILIARY ENERGY SYSTEM: Gas-fired hot water heater. The existing water heaters are used for individual dwelling hot water storage and for supplying energy boost.

DOMESTIC HOT WATER SYSTEM: The solar energy system is for domestic water hot water heating only. For description system components, see collector, storage, and distribution above.

COOLING: Not applicable.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0059,

SOLAR HEATING AND COOLING DEMONSTRATION - FORT COLLINS, COLORADO

Unknown, Solar Environmental Engineering Construction Co., *P.O. Box 1914, Fort Collins, Colorado* 80522

PROJECT SUMMARY: The project consists of a two-story, 2,352 square foot single family detached dwelling with a solar heating and domestic hot water preheating system. Window openings have been minimized to reduce heat gains and extra insulation added to walls, roof and ceiling to reduce heat losses. The chimney is centrally located in the home to maximize the amount of radiant heat available to occupied areas. The exterior walls are covered with cedar siding, while cedar shakes protect the roof.

SOLAR APPLICATION: Heating and hot water.

COLLECTOR: 672 square feet liquid-cooled flat-plate manufactured by Reynolds.

STORAGE: 1,245 gallons of water and corrosion inhibitor within an insulated 11' diameter x 7' storage tank. A separate 75 gallon preheat tank supplies the domestic hot water system.

DISTRIBUTION: Hydronic. A heat exchanger transfers heat between the collector loop and the solar storage tank. Water from storage either goes directly to a baseboard heater or if it needs supplemental heat is passed through the boiler.

AUXILIARY ENERGY SYSTEM: Electric boiler. The boiler in-line between storage and baseboard heaters provides auxiliary heating.

DOMESTIC HOT WATER SYSTEM: Domestic hot water supply line passes through the preheat water prior to entering a conventional 100 gallon water heater.

COOLING: Natural ventilation.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0060,

DEVELOPMENT OF AN INTEGRATED SINGLE FAMILY SIZE SOLAR HEATING, COOLING, AND HOT WATER SYSTEM USING AIR COLLECTORS AND A HEAT PUMP (ABBREV)

L.E. Shaw, Solaron Corp., *4850 Olive St., Commerce City, Colorado* 80022 (NAS8-32249)

Solaron will design and study three configurations of solar assisted heat pump systems and four configurations of solar assisted desiccant systems. The most optimum system will be selected and a single family residential heating, cooling and hot water system will be chosen for two sites. These two sites are Akron, OH and Arkansas. Air heating flat-plate collectors with rock storage will be used at both sites. Marshall Space Flight Center will monitor project progress. (DOE/CS-0010)

SUPPORTED BY U.S. Dept. of Energy, Office of Conservation & Solar Applications, Div. of Solar Applications

1.0061,

SOLAR HEATING AND COOLING DEMONSTRATION - AIR FORCE ACADEMY, COLORADO

Unknown, U.S. Dept. of Defense, Air Force, *Air Force Academy, Colorado Springs, Colorado* 80840

Operational Date: April 1977. Building Type: Residential, single family, 1,238 sq. ft. Application: Heating and Hot water. Collector Type: Liquid flat-plate, (sq. ft.): 742. Storage Type: Water 200 sq. ft.

OBJECTIVE: To compare alternative methods of heat storage for all collectors utilizing existing basements.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0062,

SOLAR HEATING AND COOLING DEMONSTRATION - AIR FORCE ACADEMY, COLORADO

Unknown, U.S. Dept. of Defense, Air Force, *Air Force Academy, Colorado Springs, Colorado* 80840

Operational Date: April 1977. Building Type: Residential, single family, 1,238 sq.ft. Application: Heating and Hot water. Collector Type: Air flat-plate (sq. ft.): 768. Storage Type: Rock 600 sq. ft.

OBJECTIVE: To compare alternative methods of heat storage for air collectors utilizing existing basements.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0063,

SOLAR HEATING AND COOLING DEMONSTRATION - AIR FORCE ACADEMY, COLORADO

Unknown, U.S. Dept. of Defense, Air Force, *Air Force Academy, Colorado Springs, Colorado* 80840

Operational Date: April 1977. Building Type: Residential, single family, 1,238 sq ft. Application: Heating and Hot water. Collector Type: Air flat-plate (sq.ft.): 704. Storage Type: Change of phase 636,000 Btu.

OBJECTIVE: To compare alternative methods of heat storage for air collectors utilizing existing basements.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0064,

SOLAR HEATING AND COOLING DEMONSTRATION - WESTMINSTER, COLORADO

Unknown, Waverly Homes Inc., *Westminster, Colorado* 80030

The project combines a 946 square foot, two story contemporary ranch house with a solar space heating system. The solar collector is housed in a separately detached structure adjacent to the dwelling. Energy conserving features include 2' x 6' studs used for exterior walls spaced 24' on center allowing for thicker insulation. A continuous soffit vent provides more efficient attic ventilation. Window area is reduced to 9 percent of the exterior surface area. These modifications and others reduce the dwelling's heat loss and improve the thermal performance of the solar energy system.

SOLAR APPLICATION: Heating.

COLLECTOR: 96 square foot air-cooled flat-plate manufactured by Sunglow. The collector is oriented 5 degrees west of south.

STORAGE: 13 tons of 3/4' to 1 1/4' diameter river rock within an insulated bin located behind the 'A' frame collector.

DISTRIBUTION: Forced air. A fan blows air through the rock storage bin warming the air for distribution throughout the house by ducts. Warm air is also blown out of a heat circulating fireplace.

AUXILIARY ENERGY SYSTEM: A fireplace and an electric resistance coil in the ductwork supplement the solar energy system as required.

DOMESTIC HOT WATER SYSTEM: Conventional domestic hot water heating system.

COOLING: Natural ventilation.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0065,

SOLAR HEATING & COOLING DEMONSTRATION - NEW LONDON NAVAL BASE, CONNECTICUT

Unknown, U.S. Dept. of Defense, Navy, *New London Naval Base, New London, Connecticut* 06320

Operational Date: April 1977. Building Type: Residential, single family, 1,447 sq.ft. Application: Heating and Hot water. Collector Type: Liquid flat-plate (sq.ft.): 576. Storage Type: Water, 200 cu.ft.

OBJECTIVE: To compare retrofitting existing townhouses with existing single family houses.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0066,

BIOLOGY OF BITING FLIES:

E.P. Catts, University of Delaware, Agricultural Experiment Station, Dept. of Entomology & Applied Ecology, *Newark, Delaware* 19711 (DEL00002-E)

OBJECTIVE: Develop ecological distribution and behavior of horse flies (Tabanidae) for development of control techniques; obtain information about black fly (Simuliidae) biology, distribution, and abundance in Delaware.

APPROACH: Characterize marsh edge concentration sites of salt marsh tabanids; identify and characterize by ground reconnaissance and infrared aerial photographs sites of greatest tabanid concentration; evaluate tabanid attractants for use in traps; observe hovering, mating and oviposition by tabanids and correlate this behavior with environmental conditions. Determine larval, pupal and adult populations of black flies and correlate with physical characteristics of inland streams and area of collection; determine species composition and ascertain if livestock are under black fly attack.

PROGRESS: Tabanidae: Analysis of the cooperative study of unbaited flytrap design effectiveness was completed. These findings will be reported in a manuscript now near completion. Two trap designs using solar heat units as attractants were developed and 4 traps (2 of each design) were constructed in cooperation with the Solar Energy Institute. These traps were completed too late for seasonal testing. Four manuscripts dealing with tabanids and biting flies were reviewed for publication in Mosquito News and the Journal of Medical Entomology.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Delaware

1.0067,

LOW COST SOLAR COLLECTION AND STORAGE SYSTEM FOR SUPPLEMENTAL HEATING OF BROILER HOUSES

N.E. Collins, University of Delaware, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Newark, Delaware* 19711 (DEL00187)

OBJECTIVE: Determine performance of horizontal plastic solar collectors using water as the collecting and storage medium. Develop computer simulation to optimize the utilization of solar heating and evaluate a pilot model.

APPROACH: Flat tube collectors and storage ponds of varying sizes and amounts of insulation will be evaluated for efficiency as heat collectors. Data to be recorded will include solar radiation (measured with Fritschen net radiometer), ambient air dry bulb and dew point temperatures, collector temperatures and the temperature gradient below the collector. All temperature data will be measured and recorded on magnetic tape by a 40 channel thermocouple reporting system. The computer simulation will consider the available solar radiation, collector and storage design, sizes, efficiencies, cost and predicted supplemental heating load. A prototype of the optimum solar heating system for a broiler house will be constructed and tested to verify the computer simulation for field applications.

PROGRESS: A major emphasis has been placed on developing a mathematical simulation of onfarm broiler production to assist in the design of a solar system for broiler houses. Although the model is still being developed, it has been used to determine (1) the heat load for a broiler house, (2) the economic level of insulation, (3) the ventilation rates for various management practices, (4) the fuel savings and cost of proposed energy conservation measures, and (5) the amount of Liquified Petroleum Gas that can be saved by a solar heating system. During the past year, two inexpensive solar collectors were assembled and tested. First, a collector of rectangular cross-section with a single thickness of clear plastic for glazing was constructed. Because condensation on the plastic glazing greatly reduced the effectiveness of the collector, testing was discontinued. Second, a horizontal tube collector was prepared for testing. Prior to testing, the horizontal tube was damaged beyond repair by a wind storm. Since similar events have been reported by others, no additional work on the horizontal tube is planned. The plan of work for the next year includes (a) refine mathematical relationships currently used in the model to improve accuracy, (b) add new variables to model to improve the simulations use as a management tool and (c) construct and test a flat plate collector that uses that broiler house roof (Text Truncated - Exceeds Capacity)

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Delaware

1.0068,

CONFERENCE ON BIOCONVERSION, MARCH 1976

P.F. Bente, U.S. Executive Office of the President, Council on Environmental Quality, *722 Jackson Pl. N.W., Washington, District of Columbia* 20006

This grant is for partial support of a conference on prospects for large-scale production of fuels, foods and chemicals through bioconversion. The conference will be held in Washington, D.C. on March 10-12 and will bring together government, industry, environmental and consumer organizations concerned with global energy sources and processes based on photosynthesis.

Bioconversion is the process by which solar energy is stored in land and water plants and transformed into strategic products through bacterial or chemical action or combustion. This broad field includes city and industry wastes, crop residues and manure, and plants grown specifically for conversion to energy. Proceedings from the conference will be available.

SUPPORTED BY U.S. National Science Foundation, Div. of Policy Research & Analysis

1.0069,

VEGETABLE VARIETY TRIALS

V.L. Guzman, Agricultural Research & Education Center, *Belle Glade, Florida* 33430 (FLA-EV-00391)

OBJECTIVE: Evaluate existing varieties and new strains and varieties of vegetables as to their suitability for commercial and home production in Florida. Such evaluation to be accomplished through the use of cooperative replicated and observational tests by interested workers whenever desirable.

APPROACH: Coordination of work will be assisted by a chairman of the project, elected annually, and specific crop subchairmen. These will encourage the planting of a crop or similar varieties in uniform plantings.

PROGRESS: Seven potato cultivars were compared in the fall and spring in organic soils for yields and fresh market quality. In the fall, Norchip and LaRouge produced higher yields than Red LaSoda (check). In the spring, New Red and LaRouge outyielded all cultivars. Superior produced very low yields. The fresh market quality of New Red and LaRouge were similar to Red LaSoda. Twenty-two cabbage breeding lines were compared for black rot resistance and fresh market quality. Considering resistance to the bacterium and quality, lines 261-265bc and 284-287bc were outstanding. A total of 85 plant selections were made. Texas Early Grano 502 and Granex hybrid onions were cured for 15 days using solar radiation under a clear plastic tunnel. This resulted in excessive curing in the top layers, probably due to inadequate air circulation in the tunnel. Tests will continue utilizing only solar energy with mechanisms for more rapid ventilation with the plastic tunnel.

SUPPORTED BY Florida State Government

1.0070,

PRELIMINARY EXPLORATORY VEGETABLES AND CUT-FLOWER RESEARCH AT GULF COAST STATION

D.S. Burgis, Agricultural Research & Education Center, *Bradenton, Florida* 33505 (FLA-GC-00001)

OBJECTIVE: Investigate new problems in vegetable and cut-flower crops on sandy soils.

APPROACH: Preliminary research and exploratory studies on production on vegetable and newer cut-flower crops; such as nutrition, breeding and pest control.

PROGRESS: In 1975 a new honeydew type melon named 'Morgan' was released. This melon has a high sugar level and a characteristic bouquet. When the maturing fruit becomes creamy white (80 days) and develops blotches or streaks of yellow color the fruit is ready to harvest. When harvested the fruit is ready to eat and requires no further treatment or storage. (D.S.Burgis). Analytical methods were developed to determine fluoride contents of soil, plant, air and water. Plant fumigation greenhouses were placed in operation for indexing plants for fluoride toxicity. Some plants found to be susceptible were: gladiolus, chives, sweet corn, poinsettias, Queen palms, Dracaena warneckii and Chlorophytum comosum. Some plants possessing resistance to atmospheric fluoride were: tomato, tobacco, chrysanthemum and Dracaena messengeana. (S.S.Woltz). Solar energy conversion research, as applied to greenhouse heating has culminated in a center bulletin offering greenhouse operators specific methods of calculating heating needs and installation of solar energy heating devices. Advanced solar energy conversion research, involving direct air heating is now an ongoing project. Efforts to decrease energy use by improving the cooling of greenhouse structures have the design and construction of a test greenhouse applying principles of evaporative cooling, natural convection and thermal gradients. (R. F. Lucas).

SUPPORTED BY Florida State Government

1.0071,

SOLAR ENERGY CONVERSION AS APPLIED TO GREENHOUSES

R.F. Lucas, Agricultural Research & Education Center, *Bradenton, Florida* 33505 (FLA-GC-01793)

OBJECTIVE: Design, construct and install a practical, moderate temperature solar energy conversion device to heat air; couple this device with heat storage systems suitable for greenhouse application; offer results of this research to the general public with emphasis on attracting manufacturers willing to construct such systems for greenhouse industry.

APPROACH: Construct varying quantities of each collector design (3 designs); construct inexpensive rock storage containers of varying designs; design, install these devices and a ducting and control system in a glass greenhouse at the Bradenton Agricultural Research Center; incorporate testing devices in said greenhouses to refine operation and equipment design.

PROGRESS: Investigations on the use of solar energy for greenhouse heating and cooling were continued with some advancements in the following areas: 1) design, installation and evaluation of solar-water greenhouse heating system; 2) design, installation and evaluation of solar rock-storage - moderate air temperature - greenhouse heating system; 3) design, installation and evaluation of solar heating system to South wing of main office building #7601; 4)evaluation of greenhouse designs in Florida with emphasis of summer cooling; and 5) development and application of modern automated assembly methods to traditional collector design and the incorporation of modern materials mainly aluminum and plastic into collector construction.

SUPPORTED BY Florida State Government

1.0072,

HARVESTING, HANDLING, PACKING AND STORAGE OF FLORIDA FRUIT AND NUT CROPS - PACKINGHOUSE HANDLING

W. Grierson, Agricultural Research & Education Center, *P.O. Box 1088, Lake Alfred, Florida* 33850 (FLA-CS-01740)

OBJECTIVE: Develop more efficient packinghouse handling methods for citrus and other fruits and nuts, including reduction of air, soil or water pollution and water consumption, increased productivity of personnel, and amelioration of working conditions.

APPROACH: All phases of postharvest handling will be evaluated with particular emphasis on standarization and mechanization of individual operations, including improvement of methods of handling, preparation, packaging, storage and shipment of fruits and nuts to ensure market acceptance, reduction of pollution and water consumption and increased productivity of personnel.

PROGRESS: Year around, biweekly pickings confirm that susceptibility of grapefruit to chilling injury is related to seasonal factors other than fruit maturity. (see also CS-01742.) Efforts to control decay of citrus fruit with beta irradiation were disappointing. A technique was developed for using CO2 (rather than EDB) in preliminary studies on methods of airing EDB out of truck loads of fumigated packed fruit. A portable filter unit using activated carbon removed 50% of EDB from a commercial truck fumigation unit. Adsorption isotherms were established for 2 grades of carbon at 20 and 30C. Solar energy used for heating air for fruit dryers provided an 8 to 10C air temperature rise. In the solar heated degreening room, fruit with mass average temperatures of 6 and 14C were heated to 30C in 12 and 9 hours, respectively. In fruit drying studies adhering surface moisture per fruit was highly dependent on fruit shape, size and texture. Eg as grams H2O per fruit: Dancy tangerine 1.78, .Hamlin orange 0.67, and Marsh grapefruit 1.55. With these values and current energy inputs, typical commercial fruit driers are approximately 10% efficient. Damage to fruit in harvesting was always higher for mechanically, rather than hand, harvested oranges and grapefruit. 'Plugging' was less with mechanically harvested but cuts, bruises and punctures were high and adhering stems remain an unsolved problem. Seven packinghouse newsletters were issued.

SUPPORTED BY Florida State Government

1.0073,

SURFACE DRYING CITRUS WITH SOLAR REGENERATED DESICCANTS

W.M. Miller, Agricultural Research & Education Center, *P.O. Box 1088, Lake Alfred, Florida* 33850 (7096-20510-014-A)

OBJECTIVE: Determine design information for fruit drying based on desiccant and solar regeneration. Design, construct and evaluate pilot system. Determine best desiccants based on regeneration, water capacities, adsorption rates and cost. Develop plans for large-scale solar regenerative dryer.

APPROACH: Survey desiccant drying techniques and direct solar regeneration systems. Design regenerative collector and fabricate. Study comparative features, e.g., single vs. double glass, natural vs. forced air, rate of desiccant flow, equilibrium moisture content at different temperatures and desorption rates as a function of these parameters. Optimum operating conditions to establish most feasible desiccants will be determined. Recommended designs and criteria will be developed for a prototype desiccant regenerative fruit dryer.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Florida - Antilles Area

1.0074,

DESICCANT DRYING AND SOLAR ENERGY REGENERATION FOR FRUIT AND VEGETABLE DRYING

W.M. Miller, Agricultural Research & Education Center, *P.O. Box 1088, Lake Alfred, Florida* 33850 (FLA-CS-01909)

OBJECTIVE: Determine and collect the required design information for fruit drying based on desiccant water removal and solar regeneration of the desiccant. Design, construct and evaluate a pilot plant fruit drying system based on desiccant dehumidification of ambient air. Design, construct and evaluate a dessiccant solar regeneration system compatible with fruit dryer requirements. Design and construct a demonstration system integrating both desiccant dehumidification and solar regeneration of the desiccant.

APPROACH: Determine feasibility of desiccant drying/solar energy regeneration as an energy alternative in fruit and vegetable surface moisture drying. Develop and design pilot plant equipment for evaluating both desiccant drying and solar desiccant drying regeneration. Fabricate a pilot system to demonstrate proof of concept for utilization in citrus and other fruit and vegetable operations.

SUPPORTED BY Florida State Government

1.0075,

INTEGRATED SINGLE FAMILY SOLAR HOT WATER SYSTEM USING TANK WITH VARIABLE SPEED PUMP CONTROL IN COLLECTOR FLUID LOOP (ABBREV)

D. Aspinwall, Solar Engineering & Manufacturing Co., *Fort Lauderdale, Florida* 33334 (NAS8-32248)

Development of an integrated single family solar hot water system using one storage tank with a variable speed pump control in the collector fluid loop.

Solar Engineering and Manufacturing Co., will manufacture and deliver a solar assisted hot water system for two residential sites. The hot water system uses flat-plate, liquid heating collectors with a variable speed collector loop pump. Improved tank insulation and variable pump speed techniques will be studied. The site locations are Loxahatchee, FL, and Macon, GA. Marshall Space Flight Center will monitor equipment performance. (DOE/CS-0010)

SUPPORTED BY U.S. Dept. of Energy, Office of Conservation & Solar Applications, Div. of Solar Applications

1.0076,

USE OF CONCENTRATED SOLAR ENERGY FOR DEHYDRATION OF FRUITS AND VEGETABLES

C.D. Beach, State University System of Florida, Florida Technological University, Graduate School, *P.O. Box 25000, Orlando, Florida* 32816 (7095-20510-011-A)

OBJECTIVE: Evaluate feasibility of energy concentrating solar assisted batch dryers to dry food products with high initial moisture such as subtropical fruits and vegetables.

APPROACH: Review available information, establish reflector configuration to provide broad area heat concentration, and ascertain optimum orientation of reflector panels. Design and construct experimental unit and empirically study operating parameters.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Florida - Antilles Area

1.0077,

GRAIN DRYING WITH SOLAR ENERGY IN THE HUMID SOUTH

C.D. Baird, State University System of Florida, University of Florida, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Gainesville, Florida* 32601 (3090-15704-021-A)

OBJECTIVE: Determine the technical and economic feasibility of using solar energy for grain drying in the warm, humid, southern part of the United States.

APPROACH: Low cost direct air heating collectors made of plastic film or built into a building roof will be tested for drying corn and soybeans in storage bins. The performance of the solar drying system will be measured and evaluated and optimum management practices for applying solar energy in the humid South will be studied. Initial tests will be with 100-bushel lots. Companion simulation studies will include use of solar energy to supplement fossil fuel dryers.

PROGRESS: University of Florida - A collector, constructed with clear polyethylene cover, a black polyethylene screen suspended plate and a black polyethylene film back plate, was tested at several air flow rates and successfully used for two corn-drying tests and three soybean-drying tests; however, initial grain moisture levels were relatively low.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Kansas - Nebraska Area

1.0078,

SOLAR GREENHOUSE HEATING AND COOLING

C.D. Baird, State University System of Florida, University of Florida, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Gainesville, Florida* 32601 (FLA-AG-01793)

OBJECTIVE: Develop and evaluate solar heating and cooling systems for greenhouses.

APPROACH: Modify existing greenhouses at Brandenton AREC to accommodate solar heating components. Emphasis will be placed on assembling a complete system as soon as possible in order to obtain data on the overall performance of the system, including the interactions between the solar collectors, thermal storage, and heat exchangers. Systems using water as the heat transfer and storage medium will be compared with systems utilizing air and rock storage.

PROGRESS: The rapid rise in greenhouse heating bills is a serious concern of the industry and has stimulated an interest in greenhouse solar heating. A complete greenhouse solar heating system constructed from commercially available components, has been tested for two seasons. This has provided information on the overall operating characteristics of a hydronic solar heating system and the interaction of its components (collector size, storage capacity, and size of heat exchangers). Since solar greenhouse heating is not presently economically feasible, using conventional components, work on low-cost components and the integration of solar heating components into the basic greenhouse structure is being conducted. Low-cost plastic film collectors have been developed for directly heating water or air, as well as a combination water storage/heat exchanger which can be placed beneath the plant-support benches. This storage/heat exchanger is constructed from inexpensive sheet metal, plastic, wood, and insulation board. The use of thermal storage rock beds under the plant-support benches is also being investigated using an inexpensive solar collector placed in the roof of the greenhouse.

SUPPORTED BY Florida State Government

1.0079,

GRAIN DRYING WITH SOLAR ENERGY IN THE HUMID SOUTH

C.D. Baird, State University System of Florida, University of Florida, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Gainesville, Florida* 32601 (FLA-AG-01852)

OBJECTIVE: Develop and evaluate grain solar drying systems.

APPROACH: Construct plastic solar collectors and conduct corn and soybean drying tests using two 100-bushel metal bins. Various air flow rates will be used. The tests will include drying experiments during the daytime hours only, drying experiments with the blowers run all day and all night, and experiments with the blowers on a humidistate setting at night. Temperatures throughout the collector, temperature profiles in the grain bins as well as the relative humidity, ambiant temperature, insolation will be monitored and recorded by a data acquisition system.

SUPPORTED BY Florida State Government

1.0080,

HARVESTING, HANDLING, PACKING AND STORAGE OF FLORIDA FRUIT AND NUT CROPS - PACKINGHOUSE HANDLING

E.K. Bowman, State University System of Florida, University of Florida, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Gainesville, Florida* 32601 (FLA-AG-01740)

OBJECTIVE: Develop more efficient packinghouse handling methods for citrus and other fruits and nuts, including reduction of air, soil or water pollution and water consumption, increased productivity of personnel, and amelioration of working conditions.

APPROACH: All phases of postharvest handling will be evaluated with particular emphasis on standarization and mechanization of individual operations, including improvement of methods of handling, preparation, packaging, storage and shipment of fruits and nuts to ensure market acceptance, reduction of pollution and water consumption and increased productivity of personnel.

PROGRESS: Experiments were done to determine susceptibility of West Indian avocado varieties to chilling injury from rapid cooling with low temperature air or water. Data were analyzed on air cooling of avocados in shipping containers. Tests were conducted to measure cooling rates of avocados as a function of water flow rate and position in load during hydrocooling in bulk. Experiments were conducted on forced-air cooling response of size 163 oranges in bulk at air velocities ranging from 5 to 400 fpm. Studied amount and type of damage on mechanically harvested Hamlin, Pineapple and Valencia oranges. Using light transmittance techniques, reflectance measurements in near infrared were made on oranges with different types of surface injuries in study to develop methods for optical detection of fruit injury. Measured light absorbance characteristics of citrus waxes, peel oil, and d-limonene. Data from research-scale solar energy roofing collectors indicated that a packinghouse metal roof serving as a collector could produce water temperatures averaging 125 F between 10:00 AM and 4:00 PM, costs $4 less per sq. ft. for conversion to collector function than manufactured conventional collector units of aluminum before installation, and require 220 to 380 weeks of use to save the initial cost compared to fuel oil at $0.30 per gallon.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Florida

1.0081,

DESICCANT DRYING AND SOLAR ENERGY REGENERATION FOR FRUIT AND VEGETABLE DRYING

E.K. Bowman, State University System of Florida, University of Florida, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Gainesville, Florida* 32601 (FLA-AG-01909)

OBJECTIVE: Develop elemental cost data covering: Desiccant materials; equipment design approaches and features. Develop appropriate rates and relationships as basis for input requirements. Carry out analytical work and develop cost relationships for selected component and system alternatives. Express results in terms appropriate for industry use.

APPROACH: Established engineering/economic techniques will be used in all steps of cost investigation. Both ownership and operating requirements will be considered in cost projections. Alternative components and systems considered in evaluation, will be selected in the light of experimental performance and potential.

SUPPORTED BY Florida State Government

1.0082,

DRYING SEAFOOD PRODUCTS WITH SOLAR ENERGY

J.C. Deng, State University System of Florida, University of Florida, Agricultural Experiment Station, Dept. of Food Science & Human Nutrition, *Gainesville, Florida* 32601 (7092-20530-002-A)

OBJECTIVE: Develop and study low cost solar dryers for drying seafood and mullet roe. Develop optimum conditions and study effects of collector material and configuration, radiation rate, air flow, on quality of products. Determine need for heat storage and potential energy savings.

APPROACH: Develop dryers designed of simple, inexpensive materials to use direct solar radiation and solar heated air (indirect). Compare natural convection with forced air. Prepare dried mullet roe, minced fish cake and fish fillets (white and dark flesh). Compare drying of fresh fish and roe, with products previously cured with salt. Compare temperatures and air velocities vs. quality of products. Develop optimum conditions for retention of quality and basic information for developing design and drying system for commercialization.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Florida - Antilles Area

1.0083,

PRELIMINARY AGRICULTURAL ENGINEERING RESEARCH

G.L. Zachariah, State University System of Florida, University of Florida, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Gainesville, Florida* 32601 (FLA-AG-00001)

OBJECTIVE: Conduct preliminary research on agricultural engineering problems.

APPROACH: Exploratory experiments are to be conducted to obtain information for detailed research planning and in preparation of project outlines.

PROGRESS: The technologic and economic feasibility of converting sugarcane production residues to utilizable energy forms is being investigated for waterwall incineration, anaerobic digestion and pyrolysis. Modeling studies have been initiated of biological and ecological systems in association with plant physiology and growth, algae production using animal waste as nutrient medium, and renovation properties of overland flow irrigation systems using high strength organic waste. Production and processing of algae for animal feed appears promising. Algae ponds with swine waste as the nutrient medium have produced several hundred pounds of feed material for animal nutrition studies. Progress is being made in use of micro-processors for remote data acquisition systems. Modeling and analysis techniques are being applied in an integrated pest management system for celery production. The subsurface drainage study for potatoes at Hastings has demonstrated techniques for increasing production and is being expanded. The infrared radiation onion curing system has been tested further and still looks promising. The potential of solar drying of grain sorghum with a low-cost plastic collector is being investigated. Studies of drip irrigation for citrus is continuing and results still appear promising.

SUPPORTED BY Florida State Government

1.0084,

GRAIN DRYING WITH SOLAR ENERGY IN THE HUMID SOUTH

C.D. Baird, State University System of Florida, University of Florida, School of Agriculture, Dept. of Agricultural Engineering, *Gainesville, Florida* 32601

Grain drying is an energy intensive process. It has been estimated that the energy used to dry the corn crop alone is equivalent to 640 million gallons of LP gas. Solar energy can be applied to grain drying with a good chance for success since grain drying requires relatively low temperatures; the heated air can be applied directly to the grain without the need for thermal storage or heat exchanges, and temperature fluctuations can be tolerated. Conditions of high humidity and temperature in the Southeast require that solar grain drying be done differently than in the Midwest where most of the research work has been conducted. Grain has to be dried faster with higher air flow rates, and probably with higher temperatures than are normally used for slow drying systems. Research is needed to develop appropriate solar collectors and management procedures for efficient solar energy applications to grain drying in the humid South. This proposed research project will develop and evaluate a low cost, suspended plastic screen collector costing around 25 cents/square ft, excluding labor. A 1000 square ft collector will be built for this purpose. A more expensive version of this type of collector, with insulation under the collector floor and possibly more than one layer of plastic screen will also be tested for possible use with high temperature, fast drying systems. Management schemes that optimize efficiency and effectiveness of solar grain drying as well as economic analyses of solar drying using the proposed collectors will be developed.

BIBLIOGRAPHIC REFERENCES: Chau, K.V. and C.D. Baird, A Modified Plastic Flat-Plate Collector for Grain Drying, proceedings of Flat-Plate Solar Collector Conference Feb. 28-Mar. 2, 1977, Orlando, Fl; Chau, K.V., C.D. Baird, and L.O. Bagnall, Performance of a Plastic Solar Air Heater, ASAE Paper No. 77-40 14.

SUPPORTED BY U.S. Dept. of Energy

1.0085,

ENERGY BASIS FOR THE UNITED STATES

H.T. Odum, State University System of Florida, University of Florida, School of Engineering, Dept. of Environmental Engineering, *220 Black Hall, Gainesville, Florida* 32611 (EY-76-S-05-4398)

Energy analysis and simulation of quantitatively evaluated models are used to determine the energy basis of present and future alternatives of environmental and energy input to the economy of humanity and nature in the United States. Work includes calculation of energy embodied in main environmental inflow, energy embodied in catastrophes and toxicity, energy embodied in landscapes, energy coefficients for environmental inflows to a simplified input-output matrix of the U.S. economy, estimation of the spectral hierarchy of components of various energy quality to be expected in the U.S. in the future, energy analysis of environmental and urban system developing with strip mining in Florida phosphate and Montana coal, net energy of new solar technology, energy analysis of fisheries and new simulation of U.S. growth based on net energy.

Included are studies to verify energy theories: correlation of cost of transport of embodied energy to quality factor of that energy; correlation of energy control with energy quality; and need to match high- and low-quality energy to maximize power and economy.

SUPPORTED BY U.S. Dept. of Energy, Div. of Biomedical & Environmental Research

1.0086,

DEHYDRATION OF SOUTHEASTERN FRUITS AND VEGETABLES BY SOLAR ENERGY

R.E. Berry, U.S. Dept. of Agriculture, Agricultural Research Service, *P.O. Box 1909, Winter Haven, Florida* 33880 (7608-20510-013)

OBJECTIVE: Develop practical dehydration process for food and agricultural products using solar energy augmented by fossil energy sources when necessary, to develop new dehydrated fruit and vegetable products.

APPROACH: Survey previous work, design and construct batch-type solar dehydrator, test dehydrator on traditionally dried as well as unique tropical and subtropical fruits and vegetables; assess and select food products most compatible with this type dehydration. Develop combination dryers with flexibility of diverting between solar and conventional energy sources. Design for optimum commercial application. Test flavor quality, storage stability of fruit and vegetable products.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Florida - Antilles Area

1.0087,

CONFERENCE ON ALTERNATIVE ENERGY SOURCES

T.N. Veziroglu, University of Miami, School of Engineering & Environmental Design, Clean Energy Research Inst, *Miami, Florida* 33124 (EG-77-G-05-5569)

An international conference on Alternative Energy Sources has been organized. The conference addressed itself to the present state and future promise for all the alternative energy sources. It included sessions on solar energy, ocean thermal energy, wind energy, hydro and salinity gradient power, nuclear breeders and nuclear fusion, synthetic fuels from coal and wastes, hydrogen production and uses, formulation of workable policies on energy use and energy conservation. The conference, which was held on December 5-7, 1977, in Miami Beach, was attended by some 900 scientists, engineers and policy makers from 30 countries of the world.

SUPPORTED BY U.S. Dept. of Energy

1.0088,

SOLAR HOT WATER SYSTEM FOR HEATING PLANT PROPAGATION BEDS

B.R. Roberts, Washington Holmes Area Vocational Technical Center, *209 Hoyt St., Chipley, Florida* 32428

This project proposes to provide an inexpensive source of solar energy to heat plant propagating beds and to provide students in plumbing and horticulture classes knowledge of possibilities of solar energy use. Procedures will include: (1) design and construction of solar hot water heating system in plant propagating beds and (2) design, construction, and maintenance of the solar hot water system by students.

SUPPORTED BY Florida State Government

1.0089,

SOLAR HEATING AND COOLING DEMONSTRATION - DACULA, GEORGIA

W. Lindsay, (No Performing Organization Reported), Dacula Georgia, *Georgia*

PROJECT SUMMARY: The project is a one story wood frame house with 1,000 square feet of heated floor area. The single family dwelling is designed for simple low-cost construction in rural areas. The number of window openings is held to a minimum to reduce heat losses; and their location is governd by the ability to control solar heat gain. As a result, the majority of windows are located on the south side of the house with an extended roof overhang to block the hot summer sun. The design includes a solar heating and domestic hot water preheating system. The solar collectors are integrated with the roof structure.

SOLAR APPLICATION: Heating and hot water.

COLLECTOR: 250 Square foot liquid-cooled flat-plate manufactured by Revere Copper and Brass with an automatic drain down for freeze protection, south-facing windows.

STORAGE: 500 gallons of water within an insulated steel tank buried adjacent to the building. Water from the tank is circulated through the collectors to capture solar energy.

DISTRIBUTION: Forced air. Heated water from the storage tank is pumped to a heat exchanger within fan coil unit for distribution by ducts throughout the house.

AUXILIARY ENERGY SYSTEM: Electric resistnce heating coil located in primary supply duct.

DOMESTIC HOT WATER SYSTEM: A water to water heat exchanger located in the central storage tank preheats the domestic hot water supply prior to passage through a conventional water heater.

COOLING: Natural ventilation.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0090,

DESIGN OF SOLAR COLLECTOR AND ENERGY STORAGE SYSTEM FOR HEATING GREENHOUSES AND RURAL RESIDENCES

N.E. Poulos, Georgia Inst. of Technology, Graduate School, *225 North Ave. N.W., Atlanta, Georgia* 30332 (7093-20690-004-A)

OBJECTIVE: Design, fabricate, test and furnish plans for a solar collector and storage system suitable for heating farm buildings, greenhouses, and rural residences with possible secondary use as an agricultural dryer.

APPROACH: Use a separate solar air heater to collect solar energy directly into a low-cost, low-profile rock storage bed 16' X 50'. Develop the most cost effective basic design for the combination collector and heat storage system including investigation of various rock coating techniques for increasing absorptivity. A number of combinations of glazing materials, air directors, controls, rock sizes, air flow rates and collector orientations will be investigated.

PROGRESS: Comparative tests of Caldwell selective paint (Solarsorb C-1077-3) and Glidden Flat Black (No. 908) showed the Glidden paint to be slightly better overall, with rock surface temperatures about 5 F higher than with the selective paint. Work with the prototype solar rock collector has shown that a single glazed collector may be satisfactory for those applications where daily temperatures reach a minimum of 40 F. For minimum temperatures below 40 F, double glazed collectors are necessary. This work has also shown that collectors which absorb and store solar energy directly require substantially larger rock than is typically used in rock storage systems. Temperature gradients in 4 inch granite reached a maximum of 5 F, resulting in too much energy being lost at night and during cloudy weather. Granite in 10-12 inch size is now being used. Single glazed collector-storage systems still appear possible for costs less than $1.00/ft with double glazed systems just above $1.00/ft.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0091,

DESIGN OF COLLECTORS AND INSTRUMENTATION FOR SOLAR DRYING OF AGRICULTURAL CROPS

A.P. Sheppard, Georgia Inst. of Technology, School of Engineering, *225 North Ave. N.W., Atlanta, Georgia* 30332 (7097-201-90-009-A(2))

OBJECTIVE: Design, fabricate and furnish plans on units for field evaluation of several different configurations of improved solar collectors for agricultural dryers specifically oriented toward reducing the fossil fuel consumption for drying peanuts, tobacco and forage.

APPROACH: The initial thrust of the research will be on collector systems which heat the air directly. Secondary effort will be expended on circulating liquid collectors. Various configurations which will improve the heat transfer processes will be evaluated and the most promising incorporated into systems. Since 24 hour drying is normally required, various types of storage will be evaluated for capacity, cost and physical suitability. Instrumentation which will make the data collected by various researchers on solar drying useful will be designed into data collecting systems.

PROGRESS: Tests conducted on the transmissivity of various glazing materials showed that cellulose acetate butyrate and cellulose acetate propionate may be very well adapted to this use. A prototype rock absorption and storage collector system was constructed and tested. In this absorber, the rock surface is painted black, to increase absorptivity. Very low air velocities are used to pull the heat down into the storage bed. Six prototype solar ponds have been constructed and evaluated. The most promising unit consists of a sealed plastic bag, with a clear top and black bottom, filled with water. In addition to the clear top, a second glazing over the bag is fiberglass. An inexpensive data collection system which scans eight inputs and writes the data on an inexpensive analog recorder has been developed.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0092,

SOLAR HEATING AND COOLING DEMONSTRATION - ATLANTA, GEORGIA

Unknown, Hooker & Barnes, *Atlanta, Georgia*

PROJECT SUMMARY: The project combines a 'colonial-styled' single family dwelling with a solar heating and domestic water preheating system. The design is a standard 1,622 square foot plan with two floors and a basement that has been modified to reduce heat losses by half. Foil-backed sheetrock, a higher grade and thickness of insulation in ceilings and walls, floor insulation where normally there is none, storm windows, and double-paned glass achieve these savings. The solar collectors are mounted on the sloping south-facing roof of the dwelling and the garage.

SOLAR APPLICATION: Heating and Hot water.

COLLECTOR: 600 square foot liquid-cooled flat-plate manufactured by Revere.

STORAGE: 2,000 gallons of water within a tank located in the basement. The tank is sized for a three to four day storage capacity.

DISTRIBUTION: Forced air. Heated water from the heat storage tank passes through coils in the primary supply duct. Air is blown past the heated coils and distributed to the living spaces by ducts.

AUXILIARY ENERGY SYSTEM: Gas-fired boiler. Water within the boiler is preheated by water for heat storage circulating through a heat exchanger within the boiler tank.

DOMESTIC HOT WATER SYSTEM: Hot water from storage preheats a 120 gallon conventional water heater through a copper heat exchanger.

COOLING: Natural ventilation.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0093,

SOLAR HEATING AND COOLING DEMONSTRATION - SHENANDOAH, GEORGIA

Unknown, Peachtree Homes Inc., *Shenandoah, Georgia*

PROJECT SUMMARY: The project combines a 1,216 square foot single family detached dwelling with a solar heating, cooling, and domestic hot water preheating system. Heat losses are reduced by added wall, floor, and ceiling insulation. 2'x6' o.c. wall studs are used to allow for the added insulation. Also, the dwelling's window area is decreased to reduce heat losses.

SOLAR APPLICATION: Heating and Hotwater.

COLLECTOR: 273 square foot liquid-cooled flat-plate manufactured by Revere. The multiple 3'x6 collector panels form an integrated roof system.

STORAGE: 2,000 gallons of water within an insulated welded steel tank located in the basement. A heat exchanger is used to transfer capture heat from the collector to the storage tank.

DISTRIBUTION: Forced air. Hot water is pumped from storage to a fan coil unit in the ductwork. Air is circulated through the coils, heated and distributed by duct to the living spaces.

AUXILIARY ENERGY SYSTEM: Gas-fired heat pump. The heat pump provides total or supplemental hot water to the fan coil as required.

DOMESTIC HOT WATER SYSTEM: The domestic hot water supply is preheated as it passes through a heat exchanger located in the heat storage tank en route to an over-sized conventional water heater.

COOLING: Cooling is achieved by circulating solar heated water through an Arkla absorption chiller. The cool water is pumped to the fan coil units for forced air distribution.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0094,

ELECTRIC EQUIPMENT AND METHODS TO ATTRACT AND/OR DESTROY PEACH AND PECAN INSECTS

J.S. Smith, U.S. Dept. of Agriculture, Agricultural Research Service, S E Fruit & Tree Nut Res, *P.O. Box 87, Byron, Georgia* 31008 (7706-20300-001)

OBJECTIVE: Develop electric equipment and methods for attracting and/or destroying economic insects affecting peaches, pecans, and other fruit and tree nut crops, particularly in the Southeastern States.

APPROACH: Design and conduct field experiments to test the suitability of existing insect trap designs for use in controlling peach and pecan insects. Design and develop new and more suitable equipment, develop testing procedures and reference standards, and perform laboratory evaluations of new attractants and equipment.

PROGRESS: Research was conducted using the BL trap as a timing device for applying insecticide sprays for hickory shuckworm control. The BL trap spray timed orchard received 6 sprays compared to 3 by the conventional calendar timed orchard. However, the degree of control could not be determined because the trees failed to set a nut crop. A bank of solar cells offer an alternative method to charge batteries for battery operated light traps. BL traps are being tested in a young pecan orchard in Central Texas for controlling the pecan nut casebearer, hickory shuckworm and other pecan insects. Nut casebearer infestation was decreased to 6-10 percent after the first generation but shuckworm infestation remained extremely high at 97 percent. Sooty mold can cause as high as 40 percent shading on pecan foliage in one week's time and as great as 60 percent over the growing season. This was determined by measuring the transmission of light through glass slides that had been placed under pecan trees to collect the honeydew deposits with the resulting buildup of sooty mold.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0095,

DESIGN AND PERFORMANCE OF SOLAR HEATING SYSTEMS FOR BROILER HOUSES

L.N. Drury, U.S. Dept. of Agriculture, Agricultural Research Service, Southeast Poultry Research Lab., *P.O. Box 1072, Athens, Georgia* 30604

The project objectives are to design, construct, and test the performance of a practicable system for collecting, storing and using solar energy to supplement fossil fuel in brooding and rearing poultry. Data on availability and variability of solar energy in Southeastern U.S. will be analyzed and used as a basis for design of a solar heating system for poultry production. Pilot system will be fabricated and tested. Based on results of pilot study, a complete prototype solar heating system for a poultry house will be designed, fabricated and installed. Broiler rearing trials will be conducted to evaluate the practicality and performance of the system, including the savings of fossil fuel that can be expected. Based on evaluation of the prototype, further improvements in system design and operation for efficacy and economy will be made and evaluated. Construction of the facility is about 80% complete, including: (1) remodeling two broiler houses and installing heating and ventilating equipment in them; (2) building a structure to support the solar collectors and house the storage tanks and auxiliary equipment; (3) fabricating 12 of the required 16 solar collector modules; (4) developing a solid-state controller integrator for recording the instantaneous and integrated isolation on a horizontal and a tilted surface; and (5) building a model of the overall facility and using it in describing the facility to individuals and groups.

SUPPORTED BY U.S. Dept. of Energy

1.0096,

DESIGN AND PERFORMANCE OF SOLAR HEATING SYSTEMS FOR BROILER HOUSES

L.N. Drury, U.S. Dept. of Agriculture, Agricultural Research Service, Southeast Poultry Research Lab., *P.O. Box 1072, Athens, Georgia* 30604 (7902-20400-001)

OBJECTIVE: Design, construct, and test the performance of a practicable system for collecting, storing and using solar energy to supplement fossil fuel in brooding and rearing poultry.

APPROACH: Data on availability and variability of solar energy in Southeastern U.S. will be analyzed and used as a basis for design of solar heating system for poultry production. Pilot system will be fabricated and tested. Based on results of pilot study, a complete prototype solar heating system for a poultry house will be designed, fabricated and installed. Broiler rearing trials will be conducted to evaluate the practicality and performance of the system, including the savings of fossil fuel that can be expected. Based on evaluation of the prototype, further improvements in system design and operation for efficacy and economy will be made and evaluated.

PROGRESS: Construction of the facility is about 80% complete, including: 1) remodeling two broiler houses and installing heating (brooking) and ventilating equipment in them; 2) building a structure to support the solar collectors and house the storage tanks and auxiliary equipment; 3) fabricating 12 of the required 16 solar collector modules; 4) developing a solid-state controller integrator for recording the instantaneous and integrated isolation on a horizontal and a tilted surface; and 5) building a model of the overall facility and using it in describing the facility to individuals and groups.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Athens Georgia Area

1.0097,

DEVELOP IMPROVED TECHNOLOGY FOR PRODUCTION OF LOW-COST QUALITY FEED PRODUCTS FROM SOUTHERN FORAGES

R.R. Spencer, U.S. Dept. of Agriculture, R.B. Russell Agricultural Research Center, *P.O. Box 5677, Athens, Georgia* 30604 (7902-20520-007)

OBJECTIVE: Develop practical methods of processing Southern forages to conserve energy and increase nutritive value and feed efficiency.

APPROACH: Investigate combination of field wilting and solar dehydration and chemical/physical treatment of Southern forages to reduce cost and improve quality (nutritive value) of the harvested crop. Forages to be investigated will include Coastal bermudagrass and arrowleaf clover. Use an inexpensive solar dehydrator to determine drying rates of the different forages. Obtain data on quality (chemical composition and digestibility) of the forages as related to treatments. Data obtained will provide the basis for maximizing processing Southern forages in least cost computerized feed formulations.

PROGRESS: The 3-year study on field wilting of Coastal bermudagrass, before dehydration, has been completed. Field wilting Coastal for 4-6 hours reduced the plants moisture content by almost 50%. Such reduction in the moisture content of grass would save over 40% of the fuel required for total dehydration. Field wilting was found to have little effect on product quality. Crude protein, fat, fiber and ash content remained the same. Losses of carotene and xanthophyll were less than 15%. The quality of low-quality Coastal hay (6-10% protein) can be increased by chemical treatment. Heating of low quality Coastal hay at 60 C for 5 minutes with alkali increased the in vitro digestibility of the residue. At 5 and 10% of dry matter, sodium hydroxide increased

the in vitro digestibility by 17 and 49% when compared to the untreated controls.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Athens Georgia Area

1.0098,

INCREASED EFFICIENCY IN POULTRY PROCESSING PLANTS THROUGH IMPROVED WATER UTILIZATION

W.K. Whitehead, U.S. Dept. of Agriculture, R.B. Russell Agricultural Research Center, *P.O. Box 5677, Athens, Georgia* 30604 (7902-20530-006)

OBJECTIVE: Minimize the amount of water and energy used for processing poultry while maintaining sanitary plant conditions by improving or changing processing methods and equipment to provide more effective use and increased reuse of the water and energy.

APPROACH: Evaluate water and energy requirements and consumption for poultry processing operations and measure pollutants in the wastewater at critical points in processing plants. Develop improved or new methods for more efficient use of potable water required for processing. Evaluate methods and equipment for treatment of waste water for possible reuse or prior to discharge and for recovery of heat energy from processes. Construct prototype devices and systems for tests in pilot plant and commercial operations and publish resulting design specifications for industry use.

PROGRESS: A pilot-scale short-term activated sludge waste treatment system was constructed and installed at a commercial poultry processing plant. The system was started and operated at various hydraulic flow rates to determine operating characteristics and waste reduction effeciencies. A laboratory study using sand columns as filters for treating poultry processing plant lagoon effluent showed sand filters to be a promising advanced treatment method. Based on results from this study, pilot-scale sand filters were designed and an agreement reached with a commercial processing plant to install and operate the units at their site. A low-cost aluminum flat-plate heat exchanger was assembled and tested in a commercial processing plant to recover heat energy from the scalder overflow. A full scale stainless steel flat-plate exchanger is being designed for continuing the studies. Low cost solar panels were tested for supplemental process water heating.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Athens Georgia Area

1.0099,

USE OF SOLAR HEATED AIR IN AGRICULTURE

B.D. McLendon, University of Georgia, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Athens, Georgia* 30602 (GEO00529)

OBJECTIVE: Evaluate the characteristics of selected types of air heating solar collectors operating in conjunction with agricultural product drying systems and environmentally modified animal housing and develop guidelines for operation of solar assisted drying systems in the Southeast.

APPROACH: Commercially available and experimental collectors will be tested over various volumetric flow rates and conditions. A prototype drying system will be used to evaluate product drying characteristics a linear system model will be developed for optimizing system components. Solar energy with rock storage of heat supplemented as necessary with electric heat will be used for brooding baby chicks confined for 4-wks to a 1/3-section of a broiler house. Attempts will be made to adapt portions of the system for environmental modifications in swine and calf housing.

PROGRESS: Several types of solar collectors coupled to prototype drying facilities are in use. Soybeans, wheat and corn have been successfully dried. Energy requirements for Soybeans were 0.677, 0.336 and 0.078 KWH/Bu.Pt. for conventional, solar assisted, and solar treatments respectively. Evaluation of collectors continues.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Georgia

1.0100,

USE OF SOLAR HEATED WATER IN AGRICULTURE

B.D. McLendon, University of Georgia, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Athens, Georgia* 30602 (GEO00599)

OBJECTIVE: Optimize the relationship between solar collector size, efficiency, energy storage tank size, capacity of the supplemental heating system and rate of water use for selected systems. Evaluate several methods of using solar assisted water heating systems for underfloor heating of a concrete slab floor in animal housing and greenhouses.

APPROACH: A mathematical analysis of the interrelationships between solar collector size, supplemental energy, system efficiency, storage tank size, and water use rate will be made and the analysis results will be verified experimentally. A mathematical analysis of a floor underheat system will be made and two test sections (a 4'x4' and 4'x8') will be made to evaluate the design equations developed. Using the design procedure developed, a concrete slab underheat system will be incorporated into broiler housing and greenhouses.

PROGRESS: Two types of low cost water heating solar collectors have been built and are currently being evaluated. One is a lightweight collector that could be mounted on the rooftop. CPVC pipes are used as the fluid channels and commercially available fiberglass is the cover. The collector has an efficiency of approximately 27%. The second type of collector currently being tested consisted of PVC pipes embedded in 7.62 cm bed of asphalt paving material. The cover is a commercially available fiberglass. Efficiency measurements are currently being made. Both collectors could be constructed for less than $33/m . Three concrete slabs with heating pipes were poured. One slab contained 1.27 cm. standard iron pipe and the other 1.27 PVC pipe. The PVC pipes were embedded in the slab by two methods to evaluate the potential thermal expansion problems that might exist when heating with the pipes. No thermal expansion problems were encountered. Test were run to develop design information for utilization of PVC pipes in concrete. Increase of heating fluid temperature by 8 to 12 degrees C will allow performance comparable to conventional iron pipe systems. Publication of resulting design information is in progress.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Georgia

1.0101,

ENERGY CONVERSION FROM SOLAR TO MECHANICAL POWER

C.E. Rice, University of Georgia, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Athens, Georgia* 30602 (GEO00591)

OBJECTIVE: Determine the performance and efficiency of a solar collector - vapor engine system for converting solar energy to mechanical power delivered by a rotating or reciprocating shaft.

APPROACH: A flat plate collector will be used to vaporize Freon 114 and other Freon. The vapor will be used to power a piston engine and an air motor. The vapor will be condensed and the liquid pumped into the collector. Radiation levels, temperatures, pressures and flow rates will be determined. Engine or motor RPM and torque will be determined for hp calculation. Efficiencies will be calculated. Solar/mechanical system will be field tested as drive system for water pump of solar collector unit.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Georgia

1.0102,

ENVIRONMENT MANAGEMENT IN A BROILER HOUSE

J.D. Wilson, University of Georgia, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Athens, Georgia* 30602 (GEO-03-0447)

OBJECTIVE: Develop an environmental system for the production of broilers under Southeastern conditions, including such features as clear span construction, minimization of sanitization time, fully insulated and mechanical ventilated with necessary controls. Evaluate experimental feeders and waterers as to their amenability to a controlled environment system. Adapt all findings to existing broiler houses.

APPROACH: Evaluations, as determined by air temperatures and velocities, moisture, ammonia concentration and air-mixing, of the winter and summer ventilation systems will be made. The controls for ventilation and supplemental floor heat will be designed and tested. With the aid of numerous transducers the measurement of solar collector performance and of heated slab floor performance will be evaluated. Consideration will be given to the findings of related projects so that the environmental control system will be influenced by and adapted to the selected system of feeding and watering. The influence of the selected environments on the production efficiency of broiler chickens will be evaluated by feed efficiency and market gradings.

PROGRESS: Testing to determine the effect of air dry-bulb temperature, air relative humidity and ventilation rate per bird on the weight loss, body temperature and respiration rate of mature broilers in a simulated transport during a four hour test period has beed started. No results are available as yet.

SUPPORTED BY Georgia State Government

1.0103,

NURSERY AND GREENHOUSE MECHANIZATION

B.P. Verma, University of Georgia, Georgia Agricultural Experiment Station, Dept. of Agricultural Engineering, *Experiment, Georgia* 30212 (GEO01201)

OBJECTIVE: Research and develop facilities and equipment for an efficient energy and labor utilization in the production of nursery and greenhouse crops.

APPROACH: Growing areas with controlled traffic pattern will be used in conjunction with a mobile platform. Equipment and facilities will be developed for fertilizing, materials handling, weather protection, etc. Recessed growing areas in the ground with subsurface irrigation and solar heating will be tested to determine if greenhouse could be replaced with such arrangements. A systems analysis of the production systems is also planned.

PROGRESS: A bottom unloading hopper was designed to study metering rates of wet and dry peat moss and pine bark. The test variables included were: bin wall angle, height of material in the bin, belt speed, moisture content, and gate opening. A linear relation between the belt speed and metering rate was obtained. There was no effect due to the height of material and with bin wall angles less than 50 bin wall angle. Research with the development of slow release herbicide in tablet form continues. Field results showed localized control for approximately 2 in. around the tablets, under overhead sprinkler irrigation. Three or four tablets in each 6 in. container provided good weed control. A multi-level trailer for moving containers is near completion. The top levels of the trailer will move up and down for loading and unloading. A time and motion study will be made utilizing especially designed pallets.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Georgia

1.0104,

REDUCING THE COST OF PEANUT HARVESTING, DRYING AND CURING IN THE SOUTHEAST

J.L. Butler, University of Georgia, Georgia Coastal Plain Experiment Station, Dept. of Agricultural Engineering, *Tifton, Georgia* 31794 (7702-20190-002)

OBJECTIVE: Develop methods and equipment which will reduce the cost of harvesting and curing peanuts by reducing losses and damage and minimizing fossil fuel consumption in drying.

APPROACH: New mechanisms will be investigated to harvest peanuts and remove the foreign material, which presently causes problems in handling, drying and storing. The effect of chemicals which alter growth and fruiting habits of peanuts will be evaluated to see whether they can be used advantageously in combination with harvesting equipment to reduce losses, damages or drying requirements. Non-conventional land preparation and planting methods will be evaluated for effects on yield and harvesting efficiency. Various methods of collecting, storing and using solar energy to replace a portion of the fossil fuel energy currently required to dry and cure peanuts will be evaluated. From these studies, recommended equipment, practices and procedures will be developed.

PROGRESS: Peanuts with a normal maturity time of 135-140 days after planting were harvested at weekly intervals beginning 127 days after planting. Yields were 3670, 3952, 3928, 4108, 4060, and 3638 pounds per acre for the six successive harvests. The corresponding monetary values based on grade and yield were $637, $643, $573, $561, $663, and $601 respectively. The range and inconsistency reflect the indeterminate nature of the peanuts. Tests conducted with the experimental digger picker showed less LSK, less foreign material and less total damage than conventionally harvested peanuts. The harvest-

ing efficiency was only about 80 percent. Tests with an experimental peanut recleaner showed that about one-half of the foreign material and LSK could be removed from combine run peanuts by the unit. Solar energy collectors were used to furnish heat energy for peanut drying. Tests showed that conventional driers supplemented with solar energy required about half as much LPG per pound of water removed as did the conventional. Seven methods of primary land preparation indicate that the conventional, deep turning with the burial of previous crop residue resulted in the highest yield. Planting six rows of peanuts on a conventional bed, instead of two, increased yields for runner and spanish type by 11 and 15 percent respectively. There was no difference in yield for the Virginia type.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0105,

A SOLAR ENERGY - PETROLEUM CONSERVATION SYSTEM FOR CURING TOBACCO

J.S. Cundiff, University of Georgia, Georgia Coastal Plain Experiment Station, Dept. of Agricultural Engineering, *Tifton, Georgia* 31794 (7098-20190-010-A)

OBJECTIVE: Determine the system parameters for a tobacco curing system which utilizes solar energy, supplemented by a heat pump to totally eliminate LP gas and fuel oil for tobacco curing.

APPROACH: A scale prototype consisting of three one-fifth scale curing chambers, an existing flat plate solar collector and rock storage and an electric heat pump, to be used in off-peak hours, will be used to cure tobacco in the bulk. Heat from the solar collector will be stored in the rock bed to be used in the curing phase. For the high temperature 170 F, steam drying phase, an electric heat pump will be used to elevate the temperature. Heat will be recovered from the exhaust air during the final phase of curing. A microcomputer will be used to optomize the control functions during the testing of the prototype.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0106,

MOLD PREVENTION WITH ENERGY CONSERVATION DURING HARVESTING AND CURING PEANUTS IN THE SOUTHEAST

J.M. Troeger, University of Georgia, Georgia Coastal Plain Experiment Station, Dept. of Agricultural Engineering, *Tifton, Georgia* 31794 (7702-20190-001)

OBJECTIVE: Develop equipment and procedures for harvesting, curing and storing peanuts to minimize mycotoxin and mold contamination, and maintain maximum quality with a minimum expenditure of fossil fuel energy.

APPROACH: Determine harvesting and curing procedures that will maintain maximum quality of peanuts by minimizing mold and mycotoxin contamination. Determine procedures which will make maximum use of solar, wind and other sources of energy which will decrease dependence on fossil fuel energy and maintain maximum quality. Laboratory controlled experiments will be used to determine limiting conditions. These parameters ill then be applied to production quantities. Equipment and recommended practices will be developed and made available to the peanut producer.

PROGRESS: Samples of Florunner peanuts were held at 81 F (27.2 C) and relative humidities of 72, 84, and 95 percent for 1 to 10 days in each of two tests. The initial moisture content of the peanuts for the two tests were 21 and 29 percent, wet basis. Aflatoxin developed at all levels of relative humidity in 7 days when the initial moisture content was 21 percent. In the peanuts with 29 percent initial moisture content, aflatoxin had developed by the third day at all relative humidity levels. Samples of nine varieties of peanuts were held for 7 days at 81 F (27.2 C) and 85 percent relative humidity. The average aflatoxin range, by types, was from 42 to 228 parts per billion. There is no apparent relation between the levels for two consecutive years, suggesting that growing and harvesting conditions have more effect on aflatoxin than variety.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0107,

DEVELOPMENT OF EQUIPMENT AND PROCEDURES FOR IMPROVED HARVESTING AND PROCESSING SOUTHEASTERN FORAGES

J.L. Butler, University of Georgia, U.S. Dept. of Agriculture Agricultural Research Service, Harvest Proc Strg Res, *Tifton, Georgia* 31794 (7702-20190-003)

OBJECTIVE: Develop improved equipment and procedures for producing, harvesting, processing and storing southeastern forage crops which will reduce the cost and energy requirement and enhance the nutritive quality.

APPROACH: Different machines and methods will be developed which will result in increased stand, with minimum disturbance to the sod, of seasonal annual forage crops overseeded on perennial sod crops. New machanisms will be developed to cut and prepare forage crops for field wilting. These will position the forage crop to take maximum advantage of solar, wind and other sources of energy. Processing and storage methods will be evaluated on the basis of energy requirements and effectiveness in converting forage into meat and milk. This work will be cooperative with plant and animal scientists, both state and federal.

PROGRESS: Arrowleaf clover was cut, field wilted, chopped and then processed by ensiling or dehydrating and pelleting. The initial moisture content of the ensiled material was 60 percent, wet basis. Due to a rain, the initial moisture content of the material to be pelleted was 80 percent. The two products were fed to dairy heifers. Dry matter intake, as a percent of body weight and average daily gains were 2.73 and 2.1 for the silage and 2.66 and 1.8 for the pellets. The experimental drier was modified so that the air passed downward in the two final sections. This change allowed about 10 percent increase in air velocity and a corresponding increase in drying rate. The experimental crusher reduced drying time for Coastal bermudagrass by about one day compared to conventional. Dry matter losses in the field averaged about 14 percent with the experimental unit compared with 10 percent for the conventional mower crusher.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0108,

ENERGY USE IN MARKETING AND PROCESSING FOOD AND FIBER COMMODITIES

J.M. Broder, University of Georgia, U.S. Dept. of Agriculture Commodity Economics Div., Poultry Products Program Area, *Athens, Georgia* 30601 (CE-08-077-13-01-X1)

OBJECTIVE: Develop estimates of energy required in marketing food and fiber commodities, present and future. Conceptualize and develop analytical models for aggregating and disaggregating energy data and studying alternatives relating to energy forms, locational, geographical and seasonal problems, commodity shifts, and long-range programs. Analyze potential energy use with alternative marketing methods, new technology, and conservation practices. Determine effects of modification of regulations on energy use by agricultural marketing firms and of national and international energy policies on costs, prices, location of production and marketing functions, and commodity mix. Suggest policy alternatives which would maintain a viable agriculture.

APPROACH: Develop estimates of energy use in the marketing of selected food and fiber commodities. Conceptualize and test an accounting model for measuring energy use in agricultural marketing and evaluate potential energy requirements with alternative marketing systems. Estimate State energy requirements for marketing by type of energy, season, commodity and function. Study effects of modified transportation and environmental regulations. Develop structural profiles of agricultural marketing firms with inputs and cost measurements.

PROGRESS: Much of the previous work has been reported under the NEAD energy matrix project on production and CED Program Area projects not specifically on energy. Completed poultry and egg inputs for ERS production energy data base. Published reports on energy savings for poultry, dairy, livestock, field crops, orchard crops, and vegetable crop producers, energy use and conservation in poultry and egg production and marketing, potential use of solar energy in heating broiler houses, potential energy savings in feeding livestock and poultry, and on energy research needs. Completed studies on energy use in poultry processing and rendering in the South. Collected additional energy use data on poultry and egg production and marketing. Began collection and analysis of energy use in marketing all agricultural commodities.

SUPPORTED BY U.S. Dept. of Agriculture, Economics Statistics & Cooperatives Service, Commodity Economics Div.

1.0109,

AIR-DRYING, FREEZE-DRYING AND OSMOVAC-DEHYDRATION OF FOODS WITH SOLAR ENERGY

J.H. Moy, University of Hawaii System, Manoa Campus, Agricultural Experiment Station, Dept. of Food Science & Technology, *Gilmore Hall, Room 102, Honolulu, Hawaii* 96822 (7092-20510-008-A)

OBJECTIVE: Develop air drying of foods with solar energy emphasizing design efficiency, sanitation, product quality and economics. Explore, test, and develop freeze frying and osmovac-dehydration of selected foods with solar energy. Determine conventional energy conserved resulting from solar energy use.

APPROACH: Design and construct dryers to use solar radiation to dry root crops and tropical fruits and vegetables. Measure incident radiation, air movement, heat and mass transfer, and thermal properties of samples. Design and construct systems for freeze drying selected foods with solar energy; also system for osmovac-dehydration of fruit pieces, using solar energy for syrup concentration and increased osmotic rate at higher temperature.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Florida - Antilles Area

1.0110,

MANAGEMENT AND UTILIZATION OF REARING WASTE FROM MASS REARING OF FRUIT FLIES

P.Y. Yang, University of Hawaii System, Manoa Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Gilmore Hall, Room 102, Honolulu, Hawaii* 96822 (5090-20225-005-A)

OBJECTIVE: Develop improved methods for managing waste resulting from mass rearing of fruit flies to reduce total cost of operating rearing facilities.

APPROACH: Evaluate methods for accumulation and handling of fruit fly waste and investigate methods for waste disposal and utilization, including the production of methane gas and devising ways to use such gas to help meet heat energy needs of an insect-rearing facility.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, California - Hawaii - Nevada Area

1.0111,

SOLAR STILL AND GREENHOUSE - SALT WATER DISTILLATION AND AGRICULTURE

Unknown, University of Hawaii System, Manoa Campus, Graduate School, *Spalding Hall, Room 359, Honolulu, Hawaii* 96822

No summary has been provided to the Smithsonian Science Information Exchange.

SUPPORTED BY Hawaii State Government

1.0112,

SOLAR STILL - GREENHOUSE PROJECT

B.Z. Siegel, University of Hawaii System, Manoa Campus, School of Arts & Sciences, Dept. of Microbiology, *2444 Dole St., Honolulu, Hawaii* 96822

A prototype of the solar still greenhouse has been constructed and is currently in position at the Oceanic Foundation. An intermittent salt water supply has been provided and the quantity of fresh water generated by evaporation and recondensation in the apparatus has been measured. The amount of water which this system can yield will, to a considerable extent, determine the types of crop plants which may be maintained in such an apparatus. Experiments with various species of vegetation have been initiated.

This prototype has been designed to be used on land with a salt water supply, as opposed to the concept of a floating solar still greenhouse where evaporation would occur directly from the ocean surface and the fresh water generated in the system could be used immediately by the plants.

SUPPORTED BY Hawaii State Government

1.0113,

ASSESSMENT OF THE POTENTIAL OF WIND AND SOLAR ENERGY IN HAWAII

J.W. Shupe, University of Hawaii System, Manoa Campus, School of Engineering, Dept. of Civil Engin, *Bachman Hall, Honolulu, Hawaii* 96822

The objectives of this project are to: (1) Obtain an accurate record of wind and solar insolation patterns throughout the State; 2) Assess the feasibility of wind and solar energy conversion for Hawaii; and 3) Establish criteria for optimum site selection, ooth for demonstration projects and for competitive energy installations. This project integrates three related tasks. The first two consist of comprehensive wind and solar insolation surveys, and the third task will examine in a systems context possible applications of wind and solar energy for direct usage as well as conversion to electricity.

The wind survey will be used to develop an understanding of the causes of wind time and space fluctuations and to establish criteria for identifying the best wind-power generator sites. The solar survey will expand the existing network of solar measuring stations, with the objective of evaluating and mapping the energy potential of solar radiation over Hawaii. The applications study will examine the potential of utilizing solar and wind energy for irrigation, pumping, sewage treatment, corn drying and residential hot-water heating.

SUPPORTED BY U.S. National Science Foundation, Div. of Advanced Energy & Resources Research & Technology

1.0114,

AIR DRYING, FREEZE DRYING AND OSMOVAC-DEHYDRATION OF FOODS WITH SOLAR ENERGY

J.H. Moy, University of Hawaii System, Manoa Campus, School of Tropical Agriculture, Dept. of Food Science & Technology, *Gilmore Hall, Honolulu, Hawaii* 96822

The work proposed in this project envisions approaching and solving the problems on several fronts and comparing their merits and drawbacks. Air drying and osmovac-dehydration will be by direct absorption of solar energy and also in a system combined with heated air. Freeze drying will be in vacuo using solar energy as the heat of sublimation, and in a non-vacuum system using desiccated warm air. All of the drying studies have the main objective of conserving conventional energy by replacing some or all of it with solar energy. The work plans will encompass the following subject areas: (1) adapting and developing current food processes (i.e., air drying and freeze drying) to enable incorporation of lower quality energy sources to produce acceptable food products; (2) developing food process changes and/or new processes or products amenable to increased applications of solar energy (i.e., osmovac-dehydration where both steps could use solar energy to improve dehydration rates); and (3) incorporating limited studies on the feasibility of applying solar energy to specific commodities (such as tropical food products, e.g., root crops and tropical fruits) as related to geographic regions, the local food processing industries, and availability of solar energy. The knowledge gained from these studies is expected to result in some energy saving, and in advancing the technology of solar dehydration.

SUPPORTED BY U.S. Dept. of Energy

1.0115,

APPLICATIONS OF SOLAR ENERGY TO HEATING AND AIR CONDITIONING HOUSES

M. Qutub, Kovacs & Qutub Inc., *Des Plaines, Illinois* 60018

DESCRIPTION: The research we are conducting deals with using solar energy in expensive houses, apartment buildings, offices and low income houses. Several foreign countries expressed interest in using solar energy for heating and air conditioning in houses, and we are trying to design a system for them.

ADDENDA: Estimated calendar year funding reported as 1975 $1,400,000.

SUPPORTED BY Kovacs & Qutub Inc:

1.0116,

PARCHING PROCESS FOR WILD RICE

R.A. Anderson, U.S. Dept. of Agriculture, Agricultural Research Service, Northern Regional Research Center, Engineering Development Lab., *Peoria, Illinois* 61604 (3102-20520-009)

OBJECTIVE: Study development of an efficient, economical process for parching wild rice.

APPROACH: Investigate in depth the parching-drying of wild rice. Determine type of equipment best suited for continuous drying and parching of wild rice. Establish operating conditions for optimum parching necessary to obtain desired organoleptic and physical characteristics of final product. Explore different approaches to parching such as micronizing and microwave heating. Study the possibilities of applying alternate sources of energy, such as solar energy, If necessary, design suitable parching equipment. Conduct cost studies to determine maximum practical monetary return for a given procedure or process.

PROGRESS: Preliminary tests on using a corn roaster for parching wild rice had given promising results, but more exhaustive studies on the use of the machine for this purpose showed this roaster to be unsuitable. Low feed rates coupled with uneven temperatures and very high rice moisture were the contributing factors. Steaming wild rice to gelatinize the starch was established as a necessary part of the process. Moisture content of green rice should be 40-50% in order to satisfactorily condition the starch. In addition to eliminating undesirable white centers in the finished rice, steaming appears to aid subsequent processing. A survey conducted to determine where wild rice breakage occurs, indicated very little kernel breakage in the harvesting and fermentation steps. Once in the plant, breakage increased dramatically, with most of the breakage taking place in the dehuller and scarifier.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Northern Regional Research Center

1.0117,

SOLAR HEATING & COOLING DEMONSTRATION - VERNON HILLS, ILLINOIS

Unknown, United Development Co., *Vernon Hills, Illinois*

The project combines heating and domestic hot water preheating system with four, two story, single family attached dwellings. Each dwelling totals 3,300 square feet of heated floor area. The wood frame building displays contemporary styling and simple details. Collectors are mounted on the sloping south-facing roof. Benefits of attached units are a reduction of heat losses and a decrease in solar system size.

SOLAR APPLICATION: HEATING AND HOT WATER

COLLECTOR: 1,250 square feet liquid-cooled evacuated glass tube module. Three concentric tubes: transparent cover, absorber with selective coating, and a feeder tube comprise each module.

STORAGE: 1,000 gallons of water within an insulated tank located in the basement.

DISTRIBUTION: Hydronic. Heated water from storage is pumped directly to valance heating units in occupied areas. When storage temperatures are insufficient the heat pump and domestic water heater provide supplemental energy.

AUXILIARY ENERGY SYSTEM: A gas-fired heat pump elevates storage temperatures prior to pumping the heated liquid to valance units.

DOMESTIC HOT WATER SYSTEM: Domestic hot water is preheated by passing the supply line through a copper shell and coil type heat exchanger in the main storage. The preheated water is stored in the tank of a conventional 185 gallon heater.

COOLING: Natural ventilation.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0118,

DRYING AND CONDITIONING OF FARM GRAINS

G.C. Shove, University of Illinois, Urbana Champaign Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Urbana, Illinois* 61801 (ILLU-10-0359)

OBJECTIVE: Development of grain drying and conditioning systems which will: Be less demanding on limited reserve energy resources, efficiently utilize unlimited reserve energy resources, in particular, solar energy, and produce grain of high quality.

APPROACH: Operating data will be collected on drying systems equipped with control devices to limit energy input as related to weather conditions. Control of energy input will be based on temperature, humidity, and grain moisture content in an attempt to optimize the utilization of energy. Solar energy collectors will be integrated into grain drying systems and data obtained to analyze the effectiveness of applying solar energy to agricuitural crop drying. Samples of grain will be evaluated in the laboratory to determine the effect of conditioning procedures on grain quality.

PROGRESS: Design parameters for integrating solar energy collectors into farm buildings to supply heat for drying grain are being determined from data obtained from solar corn drying installations. Preliminary analysis confirms that collector air velocities of several hundred ft/min are desirable for high collector efficiency; however, friction losses should not be allowed to exceed about 1.0 inch of water column. In one installation, 48 ft. of triangular duct constructed as a solar collector was used to convey solar heated air from the roof of machinery storage building to a grain drying bin. The additional few degrees temperature rise obtained as air passed through the 'solar duct' would seem to justify this procedure whenever possible in solar grain drying systems. Data obtained to determine the energy collected by similar bare plate and covered plate collectors indicated the covered plate to be about 20 percent more efficient. A solar corn drying experiment in which a 24-hour drying potential was maintained by the use of a heat pump at night when solar energy was not available indicated an electrical energy consumption of 0.18 kwh/bu per percentage point reduction in grain moisture content. This is a significantly lower energy use than grain drying systems utilizing only electrical and/or gas energy for drying.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Illinois

1.0119,

SOLAR ENERGY GRAIN DRYING (ILLINOIS)

G.C. Shove, University of Illinois, Urbana Champaign Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Urbana, Illinois* 61801 (3090-15705-005-A)

OBJECTIVE: Determine the economic and technical feasibility of using solar energy to supplement or replace other fuels in drying grain.

APPROACH: Conduct research on the application of solar energy for drying corn. Test five pairs of bins, one of each pair with a different type of solar collector and one of each pair as a check. Collector types will include commercially available plastic collectors, home built collectors made from plastic sheet, a bare plate collector made from a wind-damaged metal grain bin, a metal bin roof collector and a roof collector built into a machinery shed and used to heat air for an adjacent grain bin.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Kansas - Nebraska Area

1.0120,

SOLAR ENERGY ASSISTED HEAT PUMP GRAIN DRYING

G.C. Shove, University of Illinois, Urbana Champaign Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Urbana, Illinois* 61801 (3091-20591-010-A1)

OBJECTIVE: Determine the economic and technical feasibility of using solar energy alone and in combination with a heat pump system for drying corn.

APPROACH: Conduct research on the application of solar energy for drying corn. Explore the use of a heat pump drying system in combination with solar drying in order to maintain drying potential during the night and during other periods of low solaration. Determine the performance of flat building roof and bare metal plates on grain bin sidewalls as solar collectors for grain drying.

PROGRESS: A combination of a solar collector and a heat pump was used to dry corn in a 6000-bushel bin. The solar collector used was found to be small for this application and supplied a temperature rise of only 2-3 F to the drying air during the day. The heat pump was used at night and raised the air temperature about 8 F. The system required about 1.44 kWhrs to dry the corn from a moisture content of 20.7% to 15.2%. Tests also included four installations where solar collectors were built into the roof and sidewalls of farm buildings or on the sidewall of drying-storage bins. These more permanent collectors were added to the buildings at a cost of $2.00 per ft , or less. During the 1976 harvest season a solar assisted heat pump drier was operated from

Oct. 15 to Nov. 17 to dry 5,600 bu of 22.3% moisture shelled corn to 15%. The heat pump operated only between 8pm & 6am. Solar input was about 210 Kwh/day and heat pump energy about 240 Kwh/day, accomplishing drying with about 0.18 Kwh/bu. per percentage point of moisture removed. Records are being kept on two roof-mounted collectors on machinery storage buildings and a third collector is being constructed on the south-facing curve of a steel-arch grain drying building.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Kansas - Nebraska Area

1.0121,

SOLAR DRYING OF HIGH SPEED HAY ACCUMULATOR PACKAGES

G.C. Shove, University of Illinois, Urbana Champaign Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Urbana, Illinois* 61801 (7002-20190-014A)

OBJECTIVE: Determine the design parameters for solar hay driers, evaluate the cost benefit ratio of these driers, and investigate the relationship of hay density to the drying process.

APPROACH: An air plenum capable of drying hay packages of various sizes and density will be used to gather drying process data. This will be used in an attempt to determine optimum bale density and air entry patterns. This will be used in conjunction with a poratable covered plate solar energy collector to study collector parameters as they relate to the drying of large hay packages. The cost-benefit evaluation will be made on a solar hay drying facility which has the capacity to dry 36 large round bales, utilizing a 10,000 square foot covered plate collector which is incorporated into the roof and the south wall of the building.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0122,

REFLECTOR ENHANCEMENT OF LOW COST SOLAR COLLECTORS FOR AGRICULTURAL APPLICATIONS

G.C. Shove, University of Illinois, Urbana Champaign Campus, School of Engineering, Dept. of Mech & Industrial Engin, *2527 Hydrosystems Lab., Urbana, Illinois* 61801 (32-15-10-304)

The reflector enhancement of flat plate solar collectors is being investigated. A mathematical model was developed for predicting the performance characteristics of planar concentrating systems. Extensions of the model to more complex geometries is in progress, and experimental studies are being planned. Computer simulations are also being used to determine the improvement in collection efficiency and the economic viability of the proposed systems.

SUPPORTED BY U.S. Dept. of Energy, Unspecified Unit

1.0123,

APPLICATION OF SOLAR ENERGY TO GRAIN DRYING

G.C. Shove, University of Illinois, Urbana Champaign Campus, School of Engineering, Dept. of Agricultural Engineering, *2527 Hydrosystems Lab., Urbana, Illinois* 61801

Investigations have been made of drying shelled corn by using energy captured by solar collectors integrated into farm buildings or by solar energy collectors placed on the side walls of grain drying bins. Design parameters are being determined for integrating solar collectors into machine storage buildings and livestock shelters for grain drying purposes. Research is being conducted on farms where solar drying systems have been installed as well as under controlled laboratory conditions. Solar grain drying systems without heat storage are under investigation, including the possibility of using a heat pump to maintain a 24-hour drying potential.

BIBLIOGRAPHIC REFERENCES: Shove, G.C., Potential of Drying Grain with Solar Energy, pp. 41-45 in Agriculture and Energy, edited by William Lockeretz., Academic Press, Inc., NY, NY, 1977.

SUPPORTED BY U.S. Dept. of Energy

1.0124,

INFLATED PLASTIC STRUCTURES FOR SOLAR DRYING OF GRAIN

R.J. Buker, (No Performing Organization Reported), West Lafayette Indiana 47906, *Indiana* (3090-20592-028-C)

OBJECTIVE: Develop and test a low-cost inflated plastic structure suitable for on-farm solar drying of grain.

APPROACH: Construct and test an inflated plastic structure 20 ft. x 85 ft. inflated by a centrifugal fan. Seal the earth floor with plastic sheet, place exhaust ducts on the floor, cover the ducts with 5000 bu. of grain and dry by downward circulation of solar-heated air. Record changes in grain moisture content, temperature, spoilage losses costs.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Illinois - Indiana - Ohio Area

1.0125,

APPLICATION OF ELECTRICITY TO AGRICULTURE

J.R. Barrett, Purdue University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Executive Bldg., West Lafayette, Indiana* 47907 (IND046023)

OBJECTIVE: Investigate means of electrically attracting and destroying insects. Develop and evaluate electric soil heating systems for turf.

APPROACH: Make field comparisons of insect traps to determine the influence of variables on catches. Develop mathematical analysis procedures. Study control of insects by electrical equipment alone or combined with insecticides. Devise systems for reducing insect populations. Make studies of soil heating control systems and components in field and laboratory. From data from small plots and commercial installations estimate required energy. Design, construct and test a laboratory facility to determine the heat transfer characteristics of turf.

PROGRESS: The feasibility of drying of wheat to aid double-cropping, give more latitude in management, and to better utilize existing structure investments was preliminarily investigated. Test-weights of batch in-bin solar dried wheat averaged 61 when compared to 58 lbs/bu for wheat allowed to dry in the field. Harvest losses were reduced, and grain was of higher quality. Light-trap, sweep-net, pheromone baited sticky-board, field observation and environmental data were taken in fields known to be infested with corn rootworms, European corn borers and black cutworms. Correlation of findings is not complete. Cropping sequences and agronomic practices are also factors involved. A GASP-IV simulation language program was developed to translate data into edited files for analysis. Drafts of simulations and prediction models were developed. Relative attractiveness to insects of new lamps used for general lighting was investigated with results similar to 74. Data will be published in 76. The relationships of temperature to corn borer and black cutworm flight and response to black-light were determined from 0-55C in laboratory tests at low and moderate humidities. Males did not differ from females, and no differences due to moisture stress were observed as tested. Lower limit of corn borer activity was about 15(0)C, while black cutworm was 0 C. Southern, central and northern corn borer ecotypes were compared. Minor differences were observed.

SUPPORTED BY Indiana State Government

1.0126,

SOLAR ENERGY FOR HEATING AND COOLING GREENHOUSES AND RURAL RESIDENCES

A.C. Dale, Purdue University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Executive Bldg., West Lafayette, Indiana* 47907 (7091-20691-011-A(2))

OBJECTIVE: Develop a system for the collection, storage and utilization of solar energy for heating and cooling greenhouses, rural houses, or both.

APPROACH: A unique insulated solar energy collector will be constructed with reflector using air as an energy transfer medium. An insulated soil and groundwater field will be constructed and tested for storage of solar energy. Solar heated air will be circulated from the solar collector through the storage field 2 to 3 months prior to the heating season. Controls will be designed and the complete facility instrumented to evaluate both the collection system and earth storage system.

PROGRESS: A 3.7 by 19.5 m insulated solar energy collector was fabricated with two 3.7 by 19.5 m aluminum covered reflectors to concentrate the solar energy. The reflectors were placed at the top and bottom of the collector to reflect additional solar energy into the collector, thus increasing efficiency. Air served as the energy exchange medium between the collector and storage field of soil and groundwater. The solar heated air was blown through the insulated energy storage at a depth of seven and nine feet to transfer the heat from the solar collector. Energy collected during one week in August raised the soil temperature to 30 degrees C. However, because of flooding in Aug and Sep, the system became inoperable and the storage lost part of the energy. Operation of the collector in Oct and Nov did not prevent still further losses with the temperature dropping to about 16 degrees C on Dec. 15. Results have not been as expected because of the lack of normal direct solar radiation during the period from Oct 1 to Dec 15. This area received only 0.3 of possible solar radiation during Oct and Nov 1977. This is 67% of normal. When solar energy was available the solar collector performed quite well in providing heat. Efficiencies up to 60% were observed with an overall efficiency of 54.2%.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0127,

HEATING AND COOLING A SWINE FARROWING HOUSE WITH SOLAR ENERGY

A.C. Dale, Purdue University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Executive Bldg., West Lafayette, Indiana* 47907 (7002-20400-014-A)

OBJECTIVE: Determine the effectiveness of the Kansas State solar energy collector and storer in heating and cooling a swine farrowing shelter under Indiana conditions and observe effects of heating on control of infectious pathogens.

APPROACH: Adapt the Spillman design and construct the collector-storage unit as attachment to existing Purdue farrowing shelter. Obtain data on temperature, energy, and air flow to determine system performance. Monitor swine health and determine rate of gain of litters. Supply performance data to refine Spillman's model.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Mid Atlantic Area

1.0128,

SOLAR ENERGY COLLECTION, STORAGE, AND UTILIZATION FOR THE IMPROVEMENT OF LIVESTOCK AND CROP PRODUCTION

A.C. Dale, Purdue University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Executive Bldg., West Lafayette, Indiana* 47907 (IND46015)

OBJECTIVE: Develop solar energy collection systems, solar energy storages, and procedures for the utilization of solar energy to modify the environment for the improvement of both animal and crop production in cold and hot weather.

APPROACH: An insulated solar energy collector will be fabricated with reflectors to concentrate the solar energy. The reflectors will be placed at the top and bottom of the collector at such an angle so as to reflect additional solar energy into the collector to improve efficiency. Air will serve as the energy exchange medium between the collector and storage field. The solar heated air will be blown through pipe in an insulated energy storage field of soil and groundwater at a depth of eight feet for transfer of the heat to these materials. Starting in late August or early September, the collector will be placed in operation to build up the stored energy for use in heating animal shelters, shelters, greenhouses and farm houses in the winter. The stored heat will be recovered in a similar manner to which it was added to the soil and groundwater storage with the energy first being used to heat a greenhouse.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Indiana

1.0129,

FACILITIES SYSTEMS FOR LIVESTOCK PRODUCTION

B.C. Horsfield, Purdue University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Executive Bldg., West Lafayette, Indiana* 47907 (IND01737)

OBJECTIVE: Study and evaluate farmstead operations and components in order to assist in the se-

lection of optimally sized components and farmstead system layout.

APPROACH: Investigate, analyze, and possibly model, mathematically, the farmstead operations and their interactions for the purpose of selecting the proper type and size of equipment and facilities that will satisfy the capital and management restraints of the farmer, satisfy the legal and social requirements and maximize the objectives of the farmer. In particular, emphasis will be placed on waste handling as an element of the farmstead system in order to evaluate various waste handling systems in the context of the total farmstead operation.

PROGRESS: Drying animal wastes using solar energy is being tested on a small scale. Two portable, plastic covered green houses are being loaded daily with dairy manure and periodically stirred to determine drying rate, extent of composting action, rodent and fly problems and problems with condensation. In one of the solar dryers, the temperature of the drying material has consistantly remained above 100 F and has often been as high as 160 F due to the aerobic bacteria. This approach seems to be working well even though outside temperatures have often fallen well below freezing. Investigation of a new hog feeder concept has begun. This approach utilizes a feed overflow return in order to reduce feed loss and minimize management requirements. Two different types of silage distributors were compared to determine their effect on total capacity, particle size distribution, density, unloader performance and silage quality.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Indiana

1.0130,

PROCESSING OF AGRICULTURAL PRODUCTS

M.R. Okos, Purdue University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Executive Bldg., West Lafayette, Indiana* 47907 (IND046036)

OBJECTIVE: Develop energy efficient processing operations. Develop processing operations that minimize waste output. Develop economical processes for utilization and upgrading agricultural by-products and residues.

APPROACH: In order to accomplish the above objectives it will be first necessary to monitor the energy use and wastes output of various food and grain processing operations. This information is important in identifying the significant variables causing high energy use and waste output. Modification in present processing techniques can save energy and lower the waste load. Alternative processing techniques such as concentration of dairy and vegetable products using membrane processing can lower energy costs. Careful investigation into the fundamental mass transfer, heat transfer and kinetic properties of foods will be investigated in order to design more efficient processes. Food processing by-products such as whey and underutilized foods such as corn and alfalfa will be enzymatically, chemically and mechanically treated to provide useful products for human concumption. Fermentation techniques will also be investigated to upgrade processing residues. Once the fundamental information is obtained, computer models can be developed to aid in the selection of energy efficient, economical and waste free processes.

PROGRESS: Salt Removal from acid milk whey. A 40% removal of calcium and phosphorous at 140 degrees C for 10 minutes. The precipitation had a composition of 40% fructose and 60% ash. Lower temperatures also caused precipitation but longer times were necessary. Solar Energy Storage. Comparative tests were performed on soil, rock, and PCM (phase change materials) as to their ability to store energy. Air at 25 degrees C and 50 degrees C was pumped through beds of the storage material and the thermal response noted. The time needed to add or recover energy was shortest for rock and largest for soil. Modeling studies were performed. The cost to store a given amount of energy was found to be greatest for PCM and lowest for soil. Drying of Corn. Studies were performed on several varieties of yellow dent corn. The temperature range investigated was from 10 degrees C to 150 degrees C. Thermal conductivity, density, breakage and moisture were determined during drying. Models were developed to give detailed drying equations. Energy Cons (Text Truncated - Exceeds Capacity)

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Indiana

1.0131,

SOLAR ENERGY GRAIN DRYING (INDIANA)

R.M. Peart, Purdue University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Executive Bldg., West Lafayette, Indiana* 47907 (3090-15703-003-A)

OBJECTIVE: Determine the economic and technical feasibility of using solar energy to supplement or replace other fuels in drying grain.

APPROACH: Conduct research on the application of solar energy for drying shelled-corn. Determine effectiveness of solar collectors for heating air used for grain drying, effect of weather variations on performance of solar collectors, management techniques to prevent over-drying in bin drying systems, operational procedures needed in employing plastic-type solar collectors for drying grain. Compare performance of solar-supplemented drying systems with that of bin drying systems on nearby farms operated according to recommended low-heat air-drying procedures using appropriate measures of energy use, cost and rate of uniformity of drying.

PROGRESS: Corn was dried in two 18-ft diameter steel bins using two 1000 ft plastic solar collectors. Three 5-hp drying fans, two solar units with 1/2 hp fans, perforated false floors, two electric heaters, transition ducts, electrical wiring and control boxes, two grain distributors and a grain cleaner were installed. Two temperature recorders were connected to 34 thermocouples for temperature measurements every hour within the grain mass, at the solar collector exhaust, the drying fan-exhausts, and for outside temperature. An event recorder recorded all operating times of the fans, the collectors and the electric heaters. The heaters were installed as an alternate heat source in case of a shortage of solar energy, and under conditions of the late 1974, they were needed for successful completion of the drying process. The bins were filled to a 10-ft depth on November 19, with corn averaging 25.25% moisture content. The collectors were turned on from 9 a.m. to 5 p.m. In the 37 days of operation, 64 hours of significant solar collection were recorded and about 300 hours of operation of each 12 kw heater were indicated, so the season was not favorable for solar collection. No operating problems were encountered. Mold tests have shown no significant mold growth in corn stored from Dec. 2 to Feb. 15.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Kansas - Nebraska Area

1.0132,

SOLAR DRYING OF CROPS

R.M. Peart, Purdue University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Executive Bldg., West Lafayette, Indiana* 47907 (3090-20599-021-A1)

OBJECTIVE: Determine the economic and technical feasibility of using solar energy to supplement or replace other fuels in drying grain.

APPROACH: Concuct research on the application of solar energy for drying shelled corn. Field test a solar drying design in which approximately 2/3 square foot of collector surface is used per bushel of wet corn. Evaluate and compare the performance of such a solar drying system with a conventional low temperature electric heat grain drying system in an identical bin with identical corn during the same time period.

PROGRESS: During the 1975 harvest season a bin equipped with a Solaran collector and a stirring auger was compared with another equipped with a 13 KW electric heater. Drying to 16% moisture was completed in the electrically heated bin in 16 days and in the bin with the solar collector in 25 days. Use of the vertical stirring auger in the solar-heated bin kept grain moisture reduction essentially uniform throughout the total grain depth. This result suggests that more energy and higher temperatures can be used in bin drying systems with stirring equipment without overdrying and with reduced likelihood of deterioration in the grain layers that are normally last to dry. The stirring augers permitted the same airflow with one-fourth less fan power than was required on the unstirred bin, a power saving which offset the additional power required to pass air through the solar collector. During the 1976 season drying in a bin equipped with a solar collector and stirring augers was compared to use of a high-temperature dryer to reduce moisture from 26.5% to 22% which was followed by placing the hot grain in a bin with natural air drying. Successful drying was accomplished in both systems and energy data are being compared. Commercial solar panels and eutectic salt storage modules have been purchased to construct units for spring testing. One unit will employ solar energy as radiated, a second solar energy plus heat storage, and the third an electric low-temperature drying system.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Kansas - Nebraska Area

1.0133,

ENERGY EFFECTS IN CROP-ENVIRONMENT INTERACTIONS

R.M. Peart, Purdue University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Executive Bldg., West Lafayette, Indiana* 47907 (IND046021)

OBJECTIVE: Determine the effects of energy inputs such as solar radiation, fertilizers, tillage cultivation, harvest, pesticides and artificial drying methods on the quantity and quality of major Indiana crops including corn, soybeans, alfalfa and wheat.

APPROACH: Develop mathematical models of specific processes for simulation studies using environmental data and energy source data as inputs. These simulations can be re-run quickly and economically using historical weather data and varying energy inputs. These results may then be evaluated on the basis of effects on food production, economic returns, energy consumption or energy input/output ratios. A major application will be grain drying with various combinations of solar energy, gas fuel, and electricity. Crop ecosystem simulation work will also be continued to better advise farmers on alfalfa management. Alfalfa drying using solar energy needs research. Weather data is available; an excellent alfalfa growth simulator, SIMED, has just been developed and solar drying of corn is being studied, so the alfalfa drying work could follow naturally. Studies of energy effects on total agricultural production will also be started.

PROGRESS: A generalized crop simulation language, CROPS, was developed. It is a FORTRAN code written in the GASP-IV simulation language. It makes possible much easier computer programming of crop growth and development models by agronomic researchers. The researcher can concentrate on the quantitative relationships that influence crop growth, and overall programming problems such as interpolation of graphical data, routine collection of statistics on growth variables and printout of results are taken care of by the CROPS language. Solar energy was used as the sole heat source for drying a bin of 2500 bushels of corn. The control bin was dried with electric heat using current low-temperature drying recommendations. The solar system delivered the heat equivalent of 305 gallons of LP gas. An electrically-powered heat pump was used to dry 4000 bu. of corn in another low-temperature bin drying test. Preliminary figures indicate the heat pump provided 4.5 times as much useful heat as the actual electrical input to the unit. The added gain came from recovery of heat from the air exhausted from the grain.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Indiana

1.0134,

SOLAR GRAIN DRYING

R.M. Peont, Purdue University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Executive Bldg., West Lafayette, Indiana* 47907

A program of applying existing technology to drying grain with solar energy to determine the technical and economic feasibility of solar grain drying, and to investigate other uses of solar energy on the form compatible with grain drying. Evaluation of the need for and type of energy storage compatible with grain drying requirements.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0135,

SOLAR DRYING OF WHEAT AND OTHER GRAINS

J.R. Barrett, Purdue University, U.S. Dept. of Agriculture Agricultural Research Service, Dept. of Agricultural Engineering, *Life Sciences Bldg., West Lafayette, Indiana* 47907 (3302-20590-001)

OBJECTIVE: Determine the feasibility of using air heated by solar energy to dry wheat and other grain.

APPROACH: Evaluate and compare 3 basic drying methods through field and laboratory tests: allow natural field dry-down and then harvest; in-bin dry wheat using unheated air; and in-bin dry wheat using air heated with solar energy. Comparisons will be

made considering energy costs, fixed costs, grain quality, harvest losses, efficient use of labor, and utilization of existing equipment and facilities. A computer simulation to express how mid-summer small-grain drying can interact for more successful double-cropping of wheat and soybeans will be developed to aid future planning.

PROGRESS: Wheat was combined by cooperating farmers in late June 1976 to fill 2 18-ft bins with 1700 bu of 23% grain. One bin was dried with solar heated air, from 2 horizontal suspended-plate inflated plastic collectors and the other with unheated air. Field dry-down, grain quality, and harvest, environmental, and in-bin drying conditions were monitored. Harvest at up to 25% moisture content was accomplished without damage. In the 20-24% range heat to in-bin dry was initially needed to eliminate the high potential for spoilage, as only 7-10 days were available to reduce the moisture content to less than 18% with grain temperatures of 85-95 F. It is very questionable that this can be accomplished year after year with unheated air. Solar heating for wheat drying was adequate and acceptable for wheat harvested up to 25% moisture as long as 2 cfm/bu air flow was maintained by continuously operating fans. Some mold growth occurred in the bin dried with unheated air. Harvest of high-moisture wheat followed by low-temperature in-bin drying was found to be potentially beneficial to a grower who needs to 1) improve the quality of grain and reduce harvest losses, 2) harvest between rains in inclement weather, 3) better utilize equipment and labor over a longer harvest period, and/or 4) plant a second soybean crop up to 7 days earlier than would be possible without in-bin drying.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Illinois - Indiana - Ohio Area

1.0136,
SOLAR ENERGY GRAIN DRYING (IOWA)

C.J. Bern, Iowa State University of Science & Technology, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Beardshear Hall, Ames, Iowa* 50010 (3090-15702-002-A-1)

OBJECTIVE: Determine the economic and technical feasibility of using solar energy to supplement or replace other fuels in drying grains.

APPROACH: Conduct research on the application of solar energy for drying corn. Compare solar sector with low-temperature electric drying system for drying corn in 3300 bushel bins. Observe drying in 800-bushel storage bin in which roof and three walls have been converted to a solar collector. Where appropriate, monitor grain and air temperature, solar radiation intensity, electric energy consumption, moisture content and drying progress.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Kansas - Nebraska Area

1.0137,
A STRUCTURALLY INTEGRATED SOLAR COLLECTOR WALL FOR LIVESTOCK BUILDINGS

D.S. Bundy, Iowa State University of Science & Technology, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Beardshear Hall, Ames, Iowa* 50010 (IOW02330)

OBJECTIVE: Construct experimental integral wall collector. Gather data on operation. Evaluate design and performance of collector wall, both functionally and economically. Prepare evaluation, with recommendations for practical farm use, for technical publication and M.S. Thesis.

APPROACH: An integral wall solar collector will be constructed on isu Ag 450 Farm. Data on collector and ventilation system performance will be collected over two winters and one summer. Preliminary results will be reported in a technical paper after the first winter, and final evaluation with design recommendations will be reported in an M.S. Thesis after the second winter of operation.

SUPPORTED BY Iowa State Government

1.0138,
ENERGY CONSERVATION IN DRYING, CONDITIONING AND STORING CORN ON FARMS

G.L. Kline, Iowa State University of Science & Technology, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Beardshear Hall, Ames, Iowa* 50010 (IOW02132)

OBJECTIVE: Evaluate improved methods and equipment for drying, conditioning and storing corn on farms to conserve energy, maintain grain quality, and provide suitable capacities in relation to harvest operations.

APPROACH: Investigate the use of solar energy as supplemental heat or as the sole source of added heat for drying shelled corn in bins on farms. Design and develop solar energy collection and storage devices applicable to grain drying systems. Investigate low temperature drying and combinations of heated air and low temperature drying as methods of reducing the energy required for drying corn. Investigate methods of extending the allowable time for low temperature and unheated air drying, including chemical treatment and intermittent removal of small amounts of moisture. Conduct pilot and full-scale tests of promising drying and conditioning methods and determine capacity in relation to production and harvest operations.

PROGRESS: Corn was dried in three 18-ft dia. steel grain bins equipped with perforated floors and 5-hp fans. Fans were operated continuously during drying. For the first bin, the output of a 250-ft covered, suspended-plate solar collector made of plywood, wood framing, 6-mil black polyethelene absorber surface, and a 6-mil clear polyethelene covering was ducted to the dryer fan intake. All polyethelene had to be replaced after the previous year's use. A 4.8-kW resistance heater was on at night only. The second bin, which served as a control, had a 4.8 kW resistance heater on continuously. The third bin received output of a commercial 1280-ft flat solar collector. This 8-ft wide collector consisted of a 6-mil polyethelene cover suspended on a steel frame over a 6-mil black polyethelene absorber placed on the ground. Corn at 18% MC was placed in each bin to a depth of 16 ft. Drying was stopped 19 days later when corn was at 14.5% MC. Instrumentation monitored solar radiation, electrical energy consumption, air temperature rise, and grain temperature. Bins one, two, and three containing 3560, 3520, and 3580 bu (wet) respectively, used 4475, 5369, and 3237 kWh of electrical energy, respectively. For the 1976 season, corn drying was carried out in the same bins, with bin three equipped with a solar collector supplying heat to a 2-ton package system.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Iowa

1.0139,
SOLAR ENERGY GRAIN DRYING HANDBOOK

J.H. Pedersen, Iowa State University of Science & Technology, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Beardshear Hall, Ames, Iowa* 50010 (3091-20592-029-A)

OBJECTIVE: Develop a near-final draft of a handbook to be one of the Midwest Plan Service Series to be entilled 'Solar Energy Grain Drying Handbook', as authorized by the Midwest Plan Service Committee.

APPROACH: Contents of the handbook will include fundamentals of solar energy collection, storage, and use; fundamentals of low temperature grain drying in the North Central Central Region; needed facilities, incouding detailed construction and fabrication drawings where possible and appropriate; design and selection requirements, including how to size the various components for a given installation; applications of off-season energy use, e.g. livestock housing; and some cost relationships indicating approximate cost of a system versus its value in grain drying and other shared applications and expected life of facilities. A Work Committee of state specialists from throughout the North Central Region will direct the project.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Illinois - Indiana - Ohio Area

1.0140,
THE CLIMATIC RESOURCES OF THE NORTH CENTRAL REGION

R.H. Shaw, Iowa State University of Science & Technology, Agricultural Experiment Station, Dept. of Agronomy, *Beardshear Hall, Ames, Iowa* 50010 (IOW01852)

OBJECTIVE: Define mathematical models for: predicting development, yield and quality and assessing potential effects of weather modification in specific areas of the North Central Region. Delineate by graphs, maps, and tables the climatic variation in wind, pan evaporation, evapotranspiration, soil temperature and cumulus clouds in the North Central Region and compute parameters that will describe the probabilities of occurrence of these data.

APPROACH: Radiation, photosynthesis and evapotranspiration measurements will be made in corn and soybean canopies to provide data for testing canopy photosynthesis models. A regional model , or models will be developed to assess the effect of weather modification (precipitation) on major crop yields. Seeding responses that reflect the current appraisal of cloud seeding responses will be used to test the possible range of responses that might be obtained. Hourly wind data from Des Moines will be used to test different types of wind-energy analyses. The effect of different time sampling (1-, 3-, 6-hour) on the energy relationship will be tested. The kinetic energy formula or other energy related formulae will be used in analyzing wind data. Seasonal low-wind periods and daily probabilities will be calculated. High resolution radar contouring of precipitation rates and a dense raingage network will be used to develop detailed precipitation patterns for individual convective clouds.

PROGRESS: Solar radiation data have been edited to produce a continuous 11-year record of daily total energy per unit area. These data together with wind speed data for a comparable period are being evaluated for energy availability. Daily totals of wind and solar energy are being studied to determine their complementary nature for both short-term (1-5 day) and long-term (seasonal) applications. N-day totals (N=1, 2..., 8) of wind and solar energy are being computed to quantify energy storage requirements for wind, solar and combined wind-solar energy systems. Results of this study will permit quantification of expected reliability levels of devices using sound, solar or combined wind-solar energy. A fluxometer has been built and used to measure N(2)O fluxes. Preliminary results show an increased upward flux of N(2)O from soil surfaces after a rain. The discharge water from the Ames sewage treatment plant also shows a measureable flux. (Text Truncated - Exceeds Capacity)

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Iowa

1.0141,
IMPROVED METHODS AND EQUIPMENT FOR GRAIN HARVESTING, DRYING, CONDITIONING, AND STORAGE ON FARMS

G.L. Kline, Iowa State University of Science & Technology, U.S. Dept. of Agriculture Agricultural Engineering Res. Div., *Beardshear Hall, Ames, Iowa* 50010 (3408-15700-002)

OBJECTIVE: Develop and test improved techniques and equipment for harvesting, drying, conditioning, and storing corn on farms to reduce losses, maintain quality, reduce physical damage, and provide more efficient labor and equipment use.

APPROACH: Determine field losses and mechanical damage to corn during harvest. Continue development of belt sheller, adapting squeezing and rolling action to reduce kernel damage. Determine criteria for selection and operation of farm grain driers of different types and capacities. Develop alternate methods of conditioning, processing, and storing corn to be used for livestock feed. Analyze complete systems for harvesting, drying, conditioning, and storing corn on farms, balancing capacities with other production operations.

PROGRESS: Solar energy collectors of various types were investigated for use in drying grain. Six collectors were designed and constructed for testing. Solar collectors include air-supported and rigid frame construction. Collector surfaces were flat plate and curved plate, both covered and uncovered. Materials utilized include plastic film, rigid plastic, glass, metal and wood. Configurations include triangular, rectangular, semi-circular and circular shapes. The effect of exposure angle of the collector surface has been included in the tests. In comparative tests of the different collectors, the temperature of outside air was raised 7 to 17 F at airflow rates applicable to in-bin drying of grain. The highest temperature rises were obtained with a rigid frame, flat plate collector with cover plate and an air-supported polyethylene film collector with cover plate, both supported at the optimum exposure angle. The physical quality of 137 genotypes of corn was evaluated. Test weight was lower for large kernel genotypes due to the greater density per unit volume for small kernels. Large kernel genotypes sustained more physical damage during harvest and handling than small kernel types. Five inbreds were identified as contributing to poor physical quality and six consistently increased quality. A stationary combine cylinder was used to shell ear corn of four different varieties and five moisture contents between 16 and 32%. All measures of mechanical damage were highly correlated with moisture content and pericarp thickness.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Mid Great Plains Area

1.0142,

SOLAR ENERGY FOR CORN DRYING ON FARMS

G.L. Kline, Iowa State University of Science & Technology, U.S. Dept. of Agriculture Agricultural Engineering Res. Div., *Beardshear Hall, Ames, Iowa* 50010 (3408-20590-002)

OBJECTIVE: Design and develop techniques and equipment for collecting, storing and utilizing solar energy for drying shelled corn on farms.

APPROACH: Develop solar energy collection devices based on present knowledge and incorporate new findings on methods and materials. Design and develop solar energy storage techniques and equipment to utilize solar heat in grain drying systems. Adapt computer simulation models to predict energy collected and drying potential based on grain deterioration rates and weather records.

PROGRESS: Pilot-scale solar collectors suitable for low temperature grain drying were designed and constructed. Most of the collectors were of the flat-plate type with an absorber area of 90 square feet. Eight collectors were retained from the previous year tests and four new collectors were added. Different materials and configurations were incorporated. Reflecting surfaces were installed on selected collectors. Comparative tests were conducted during the fall at airflow rates applicable to in-bin drying of shelled corn. Solar radiation and temperature data are being analyzed to compare the efficiency of solar energy collection of the different collectors. A computer simulation program was completed for high airflow, low-temperature rise solar collectors. The model uses five energy balances to relate three surface temperatures, two channel fluid temperatures, radiation flux, and useful energy gain in two channels. Two additional relations come from integrating useful energy gain along the collector length to give fluid temperature rise.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Mid Great Plains Area

1.0143,

SOLAR ENERGY FOR GRAIN DRYING

G.L. Kline, Iowa State University of Science & Technology, U.S. Dept. of Agriculture Agricultural Research Service, *Beardshear Hall, Room 313, Ames, Iowa* 50010

Drying shelled corn on farms consumes large quantities of energy. For the low temperature drying method, low cost solar collectors can provide a small temperature rise for large quantities of air. Solar energy may provide an alternate source of energy and reduce the cost of grain drying. The objectives of the proposed research for 1977-78 follow: (A) continue development and testing of pilot-scale solar collectors to increase efficiency for low temperature grain drying and lower the cost of collectors; (B) complete a simulation model for low-temperature rise air collectors suitable for grain drying and use in evaluating new collector designs; and (C) complete an economic analysis of different types of solar collectors based on energy collected and the cost for representative grain drying systems.

SUPPORTED BY U.S. Dept. of Energy

1.0144,

WIND/SOLAR RESEACH PROJECT

D. Barnaal, Luther College, Undergraduate School, Dept. of Physics, *Decorah, Iowa* 52101

To monitor wind speed and solar energy at one site in northeast Iowa for two years to determine if a combination wind/solar may supplement each other and produce a single year-round energy source (particularly for farms). Note: January provides high average wind and low solar, August provides high solar and low wind.

SUPPORTED BY Iowa State Government

1.0145,

SOLAR ENERGY GRAIN DRYING (KANSAS)

D.S. Chung, Kansas State University, Agricultural Experiment Station, *Anderson Hall, Manhattan, Kansas* 66502 (3090-15704-004-A)

OBJECTIVE: Determine the economic and technical feasibility of using solar energy to supplement or replace other fuels in drying grain.

APPROACH: Conduct research on the application of solar energy for drying shelled corn and grain sorghum. Compare solar supplemented drying systems with conventional low-temperature drying systems operated on nearby farms in terms of energy use, cost, rate and uniformity of drying. Monitor deterioration of the grain during drying. Correlate weather data with performance of inflatable plastic tubes as solar collectors.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Kansas - Nebraska Area

1.0146,

PRODUCTION OF WATER FROM AIR

R.C. Hall, Kansas State University, Agricultural Experiment Station, Dept. of Chemical Engin, *Anderson Hall, Manhattan, Kansas* 66502 (KAN00583)

OBJECTIVE: Design and test equipment for absorbing water from the air; Make estimates of economics of proposed process.

APPROACH: Triethylene glycol will be used as first absorbent. Various contacting devices, such as towers, will be designed and their operating characteristics determined. After most efficient design is found, a large scale absorber will be built from which cost data may be obtained.

PROGRESS: This effort is designed to remove water from the atmosphere and recover it for general household and domestic use. Methods of removing water from the atmosphere include condensation onto a suitably cooled surface, adsorption onto specially prepared materials and absorption into certain compounds. Cooling can be affected by suitable capturing of atmospheric phenomenon, including solar radiation. Adsorbed water can be separated from the absorbent by utilizing solar radiation. Devices have been developed to hold an absorbind liquid in contact with humid air over a controlled period of time. A new form of 'Vapor pressure' equation have been found. Generalizations on utilizing phase transformations as a source of energy will have been found. A simplified rotor radiation meter has been developed and compared with pyroheiolimeters. A sensor has been developed to give 'point' rates of evaporation in space. These efforts are leading to developments of equipment and understandings of processes which will make it possible to recover water from the stmosphere. In addition, a new type of solar collector and improved methods of storing energy (heat) are being found.

SUPPORTED BY Kansas State Government

1.0147,

SOLAR ENERGY FOR GRAIN DRYING

R.I. Lipper, Kansas State University, Agricultural Experiment Station, *Anderson Hall, Manhattan, Kansas* 66502 (3090-20596-017-A1)

OBJECTIVE: Determine the economic and technical feasibility of using solar energy to supplement or replace other fuels in drying grains.

APPROACH: Conduct, at Manhattan, Kansas, and at other selected points in Kansas, research on the application of solar energy for drying shelled corn and grain sorghum. Explore two ways of capturing solar energy in the drying structure. In one test, an air inflated fiber glass reinforced plastic structure will house a series of small bins filled with grain. Air will be forced into the plastic structure, heated by the solar energy, and forced down through the grain and exhausted from the building through perforated ducts positioned in the bottom of the individual bins. Another approach will employ an air inflated plastic storage structure which will not only collect the heat from solar energy but wil also employ air in an attempt to remove the grain pneumatically after drying.

PROGRESS: Three approaches were attempted for using the grain storage structure as the solar collector for grain drying: (1) a 30' x 40' air-inflated plastic structure with the grain on a floor with perforated ducts leading outdoors, permitting the structure to serve as a flat-plate collector and the inflation fan to supply the drying air. (2) A cylindrical air-supported plastic bag with 6' side walls and a domed top, also with floor ducts exhausting outdoors, described as a 'grain drying bag'. (3) A clear, reinforced plastic film collector to attach to a conventional metal grain bin to serve as a wall collector. None of the structures were fabricated in time for drying use during the 1975 harvest season, so they were tested with dry grain. Structural problems were encountered with both the flat storage and the drying bag in attaining film strength, seam integrity, and bottom-edge seals to withstand the static pressure required to force adequate amounts of air down through the piled grain. For the 1976 harvest season the solar grain drying bag, the flat storage collector and the wrap-around collector were all again prepared for use, but no high-moisture grain could be obtained for the flat storage collector. The solar grain drying bag and the bin with the wrap-around collector were successfully operated to dry sorghum.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Kansas - Nebraska Area

1.0148,

SOLAR ENERGY FOR SUPPLEMENTAL HEATING OF VENTILATION AIR FOR SWINE BUILDINGS

C.K. Spillman, Kansas State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Anderson Hall, Manhattan, Kansas* 66502 (7096-20400-007-A1)

OBJECTIVE: Determine the effectiveness of a solar collector-energy storage unit for heating ventilation air for swine production in winter, to develop a control system and strategy for operation of a solar unit in a swine shelter, evaluate installation and construction methods, serviceability of materials, and operational problems, and correlate performance of a solar unit with weather and solar radiation data.

APPROACH: A solar collector-energy storage system designed and fabricated as an integral part of a swine shelter, and using minimal cost materials, will be used to head ventilation air to provide suitable environment for farrowing and brooding swine. Data will be obtained on system performance, suitability and performance of materials, and growth characteristics of swine produced in unit. Solar collector output will be correlated, using computer models, with weather and solar data.

PROGRESS: An 8' x 50' collector storage unit was designed using results from a model study completed before the starting date of this project. It has been operating since early January 1976. Data analysis will not be completed until midyear so specific results can't be cited. General observations indicate that the system has great potential for preheating ventilating air entering enclosed animal shelters. Its use can significantly reduce fuel consumption in young animal housing located in colder regions since 50 percent, or more, of the solar insolation on a vertical, south-facing collector can be added to air moving into the building. For this Manhattan, Kansas, location there have been only three days, up to May 1, 1976, when air from the collector-storage unit caused the temperature to be too high (above 87F); a normal operating temperature of 82F is maintained in the building so operation is expected to continue until early June.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Alabama - North Mississippi Area

1.0149,

DESIGN OF SHADES FOR ENVIRONMENTAL MODIFICATION IN CONFINED SYSTEMS FOR LIVESTOCK

C.K. Spillman, Kansas State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Anderson Hall, Manhattan, Kansas* 66502 (KAN00837)

OBJECTIVE: Provide design data for animal shelters which makes possible an environment with a desirable cost-effectiveness ratio when compared to open confined feedlots. Determine physical characteristics of construction materials, orientation and configuration of shelters or shades for environmental modification. Identify and quantify environmental factors that most influence the thermal environment of animals in feedlots and shelters. Investigate the relationships between shelters and waste management systems.

APPROACH: A portable lab facility will be used to study the exchange of energy between animal's haircoat and the natural environment. An energy transfer model will be developed. Both model and prototype structures will be constructed and instrumented to study the level of significant design parameters including waste management factors. Existing structures will be modified and evaluated for the influence on environment.

PROGRESS: Meters have been installed on four farrow buildings (32-stalls each) at a cooperating producer's farm to determine energy use. Environmental data as well as fan speed and heater operation are being monitored in one unit that is solar heated using the KSU solar collector-storage system. Data will be used to continue the study of energy use in farrowing houses reported last year. Instrumentation is almost complete for study of energy use in the farrowing building at Kansas State University. However, equipment problems during the fall and early winter winter heating season did not allow us to

obtain data which could be used in the computer modelling program. We have continued to use the exhaust air from this farrowing building to partially heat a small greenhouse and to provide carbon dioxide enrichment for the plants. Results of these exploratory studies have been encouraging and a proposal for outside funding has been submitted.
SUPPORTED BY Kansas State Government

1.0150,
DEMONSTRATION OF GRAIN DRYING WITH AIR FROM A SOLAR HEATER DESIGNED FOR ANIMAL SHELTERS
R.I. Lipper, Kansas State University, School of Agriculture, Dept. of Agricultural Engineering, *Anderson Hall, Manhattan, Kansas* 66502
We propose to demonstrate that a unique solar collector-storage wall designed and built for research on pre-heating ventilation air for animal shelters can be adapted at low cost to warm air for a practical and economically feasible system for low temperature grain drying. The heat provided by the 380 sq. ft. solar collector-storage wall, even with its good efficiency and with ground level reflector panels in place, will provide only enough heat in October to evaporate the moisture in about 60 bushels of corn (at 9 point moisture reduction) for each sunny day. We plan to use the heat to attain only a 3 to 4 deg F temperature rise on ambient air to speed natural air drying and provide a margin of safety on years less favorable for nature air drying. The heat available will be used on the greatest possible volume of corn. The round steel bin has been erected and the insulated air duct connected to the solar wall. Due to delayed construction and early harvest, no grain drying will be performed. Solar radiation data was obtained during the erection operations. This data will be used with a computer grain drying model to simulate the drying of typically harvested grain during the fall of 1977.
SUPPORTED BY U.S. Dept. of Energy

1.0151,
ENERGY ALTERNATIVES FOR PUMPING IRRIGATION WATER
S.J. Clark, Kansas State University, School of Engineering, Dept. of Agricultural Engineering, *Anderson Hall, Manhattan, Kansas* 66502 (KAN-05-488)
OBJECTIVE: Conduct a feasibility study evaluating energy alternatives for pumping irrigation water. Alternatives considered will not use natural gas or petroleum products but will include: Solar, wind, biomass, conversion, coal. Energy storage to facilitate efficient utilization will be considered.
APPROACH: Energy sources and storage systems will be compared considering operational and capital costs, efficiency, implementation time, environmental impacts, land use, water use, constraints due to geographic and siting problems, significant technical uncertainties, effect on foreign dependency, and social impacts. Using existing data, computer simulation studies will relate design factors and weather data to the cost and performance of energy-storage systems. Systems will be considered for individual farmers and groups of farms.
SUPPORTED BY Kansas State Government

1.0152,
ENERGY ALTERNATIVES FOR PUMPING IRRIGATION WATER
S.J. Clark, Kansas State University, School of Engineering, Dept. of Agricultural Engineering, *Anderson Hall, Manhattan, Kansas* 66502 (KAN-05-488)
OBJECTIVE: Conduct a feasibility study evaluating energy alternatives for pumping irrigation water. Alternatives considered will not use natural gas or petroleum products but will include: Solar, wind, biomass, conversion, coal. Energy storage to facilitate efficient utilization will be considered.
APPROACH: Energy sources and storage systems will be compared considering operational and capital costs, efficiency, implementation time, environmental impacts, land use, water use, constraints due to geographic and siting problems, significant technical uncertainties, effect on foreign dependency, and social impacts. Using existing data, computer simulation studies will relate design factors and weather data to the cost and performance of energy-storage systems. Systems will be considered for individual farmers and groups of farms.
PROGRESS: A feasibility study was performed to determine the most promising non-petroleum energy alternative for pumping irrigation water. Alternatives included (1) solar, (2) wind, (3) biomass conversion, and (4) direct combustion of coal. Large scale energy storage methods were included in combination with the energy alternatives. A standardized irrigation well (200 ft. to water level) was selected to provide a standard of comparison for the alternative systems. Pumping costs are being computed for the various systems. The main evaluation factor used to compare systems will be cost per acre inch pumped. Pumping cost must be less than the increase in crop value added by the water.
SUPPORTED BY Kansas State Government

1.0153,
DEVELOPMENT OF A FARM HYDROGEN FUEL SYSTEM
F.W. Harris, Kansas State University, School of Engineering, Dept. of Electrical Engin, *Anderson Hall, Manhattan, Kansas* 66502
Description: This project is concerned with the development of a system for the production, storage, and use of hydrogen as a mobile fuel on a farm. The concept involves the production of hydrogen by electrolysis, at the farm site. The required electrical energy would be derived from various solar collection schemes and from conventional electric utilities during off-peak load periods.
Addenda: Estimated calendar year funding reported as 1974 $28,000, 1975 $53,000. This project is also supported by: Kansas State University; Kansas State Government, Legislative Appropriation.
SUPPORTED BY U.S. National Science Foundation, Div. of Higher Education in Science

1.0154,
RURAL ELECTRIFICATION
R.I. Lipper, Kansas State University, School of Engineering, Dept. of Agricultural Engineering, *Anderson Hall, Manhattan, Kansas* 66502 (KAN-05-571)
OBJECTIVE: Develop confinement system for rearing channel catfish to market size in a controlled environment using recirculated, renovated water.
APPROACH: Determine conditions necessary to induce early or out-of-season spawning to reduce or lengthen seasonal availability of roe for hatching. Develop temperature controlled, disease-free hatching system using reconditioned, recirculated water. Determine design criteria for a system to rear channel catfish from fry to market size at very high population densities in enclosed, temperature controlled tanks using a bio-filter to recondition the recirculated water. Investigate best rations for tank culture and means of disease control.
PROGRESS: Studies on electrical energy use in agricultural production were started. They include the consumption of electrical power for the production of fertilizers, tires, agricultural chemicals and machinery. Surveys of the state's dairy and poultry industries are being made to estimate electric power consumption present and future in those production enterprises. A study of the energy cost vs. energy returned in increased yields of sorghum grain at different levels of irrigation water application in western Kansas were made. A survey of electric irrigation pumping loads in Kansas is being summarized by counties. An attempt is being made to acquire similar data on irrigation using I.C. engine power. Data is being taken on eight bins of corn and sorghum being dried with natural air supplemented by enough electric heat to provide a drying potential when humidity is high. These data and data from another project that uses solar energy for drying will be used to check an in-storage drying simulation model developed at Nebraska.
SUPPORTED BY Kansas State Government

1.0155,
SOLAR ENERGY FOR GRAIN DRYING
R.T. Lipper, Kansas State University, School of Engineering, Dept. of Agricultural Engineering, *Anderson Hall, Manhattan, Kansas* 66502 (KAN-05-398)
OBJECTIVE: Evaluate performance of inflatable plastic tubes as solar collectors; correlate performance of collectors with weather; establish effectiveness of supplementing natural air with solar heat for drying grain; study installation methods, maintenance problems, serviceability of collectors.
APPROACH: Two 'Helio' solar collectors will be used to acquire data on corn and grain sorghum drying in two metal bins where natural air is supplemented with solar heat. Two similar bins will be dried with natural air. Continuous air flows, 2 to 3 cfm per bu, will be used on 20% moisture grain sorghum and 20% moisture corn. Observations include initial and final moisture, weight, test weight and mold count. Temperatures, moistures, air flows and static pressures will be monitored. Weather data, air temperatures for changes across the collectors fans and grain bed, and power consumption will be measured or recorded.
PROGRESS: A grain bin complete with drying system, bottom unloading auger, and recirculating auger was erected close to a swine farrowing building that has a successful experimental solar collector-heat storage wall on its south side. The collector is ideal for the dual uses of preheating ventilation air for the building and providing supplemental heat for low temperature grain drying. The bin is connected to the collector by a 15-foot long, insulated duct with dual channels - one to carry air from the collector and the other to carry ambient air to the drying fan inlet. Air dampers permit mixing in various proportions or cutting off the collector completely. The collector is 50' x 8' and the 18'7' bin holds 3000 bu. Firm purchase contracts could not be consumated until we had firm approval on the research contract and, with last fall's grain bin sales sky rocketing as a result of the federal assistance program, delivery of all equipment came too late to accomplish drying. Test and measurements with the fully insturmental collector and dry grain in the bin are being made to predict performance through computer simulation. Actual drying tests will be conducted next fall.
SUPPORTED BY Kansas State Government

1.0156,
MINIMIZING FUEL REQUIREMENTS FOR DRYING GRAIN
H.H. Converse, U.S. Dept. of Agriculture, Agricultural Research Service, U.S. Grain Marketing Research Center, *1515 College Ave., Manhattan, Kansas* 66502 (3707-20590-005)
OBJECTIVE: Develop drying procedures and equipment that minimize energy requirements, petroleum fuel use and grain damage.
APPROACH: Laboratory, pilot plant and simulated full-scale investigations will test ways to utilize energy more effectively in drying grain and oil seeds. Investigations will include: Use of solar heat, with and without an intermediate desiccants, use of automatic controls to exploit atmospheric heat; recovery and reuse of energy from convection grain dryers; optimizing the electrical-mechanical-thermal energy balance of grain conditioning fans; and interaction of maturation and drying on quality and processing characteristics.
PROGRESS: Four pairs of tests explored further the potential of using solar energy to dry grain. Three of the paired tests compared drying with solar heated air to drying with natural air. In each test the grain dried with solar heated air dried to a lower moisture content than that dried with natural air in the same length of time. Only minor mold growth was observed in any of the test grains. The fourth test measured the performance of a solar collector with heat storage compared to a tubular collector without heat storage. The heat-storage system, consisting of 30 tons of rock, continued to deliver heat at night. The temperature of the air from rock heat-storage system was normally below ambient only during the hours of maximum sunshine. The collector-storage system accomplished 15% more drying and had 15% higher collection efficiency than the plastic tube solar collectors. A small scale grain dryer heat recovery system in which a heat pump and heat-pipe heat exchanger were combined to recover and reuse heat from exhaust air of a grain dryer was tested. The new energy required to remove water from the grain was reduced 8% using the heat-pipe heat exchanger and 50% using the heat-pipe heat exchanger and heat pump.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Kansas - Nebraska Area

1.0157,
HIGH TEMPERATURE GRAIN DRYING USING SOLAR ENERGY
B.F. Parker, University of Kentucky, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Limestone & Euclid, Lexington, Kentucky* 40506 (3090-15703-020-C)
OBJECTIVE: Determine the technical and economic feasibility of a high temperature grain drying system that uses solar energy.
APPROACH: Develop and test a concentrating type of solar collector that will provide air temperatures up to 300 F. Develop and test a heat storage unit

consisting of a series of rock beds, each with sufficient heat storage capacity to dry one batch of grain per day. Conduct an economic analysis and feasibility study of the system developed.
PROGRESS: University of Kentucky - Progress was primarily in planning, ordering equipment, constructions of a prototype rock bed storage and simulation of heat flow in the rock bed. A focusing solar collector is being prepared for mounting on the roof of the Agricultural Engineering Building.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Kansas - Nebraska Area

1.0158,
SOLAR ENERGY SYSTEM FOR AGRICULTURE
B.F. Parker, University of Kentucky, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Limestone & Euclid, Lexington, Kentucky* 40506 (KY00129)
OBJECTIVE: Determine the solar radiation concentration, conversion of solar radiation to heat and the heat transfer characteristics of a focusing solar energy collector. Determine feasible outlet temperatures and the corresponding solar energy recovery efficiency of an improved flat plane and focusing solar energy collector.
APPROACH: A focusing collector and a flat plant collector will be constructed-both have unique features which show promise for increasing the collection temperature and/or efficiency. Air will be used initially as the transport fluid with a rock bed for storage. Data from the test will be used to determine the efficiency and output temperature as well as heat transfer characteristics of the collectors. The latter knowledge will be used to improve the design. A computer simulation of the collector, storage and load will be devleoped.
PROGRESS: A flat plate solar collector research unit was constructed and tested. This collector is designed to be built as an integral part of a farm building or a residential roof. Air is utilized as the heat transfer medium. The research collector was constructed with three different types of flat plates using three collecter sections of each type for replication. Two of the collector types utilized a v-corrugated technique; one painted with black paint and the other was a solar selective surface of potassium per manganate on glossy aluminum. Initial data analysis shows that the v-corrugated units were essentially equal and at least 10% more efficient in collecting heat than the plane surface unit. A focusing collector especially designed for heating air is being constructed.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Kentucky

1.0159,
AIR DISTRIBUTION IN PLANT AND ANIMAL STRUCTURES
J.N. Walker, University of Kentucky, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Limestone & Euclid, Lexington, Kentucky* 40506 (KY00120)
OBJECTIVE: Describe air velocity, temperature and humidity distribution profiles within ventilated plant and animal structures.
APPROACH: Theoretical relationships will be developed by using energy balance techniques to describe air distribution profiles within ventilated structures. The developed relationships will permit the prediction of velocity temperature, or humidity profiles anywhere within the structure in terms of dimensional parameters which describe the air inlet configuration, structural features, and the air discharge rate. The applicability derived of the relationships will be determined by experimental tests.
PROGRESS: The continuous ventilation of a greenhouse with air pulled from a deep coal mine to eliminate or greatly reduce the energy required for environmental control of a greenhouse was investigated. It was found that the air in deep mines is the same, or slightly above, deep ground temperature. The air is also very nearly saturated with moisture. These conditions are relatively constant throughout the year with the temperature varying only a few degrees between summer and winter. In the temperature region of the United States this will be between about 52(o)F (11.1(o)C) and 60(o)F (15.6(o)C). An engineering analysis of the winter conditions in a greenhouse showed that for air flow rates of 1/2 to 1 per minute, the maximum decrease in temperatures as the mine air passed through the greenhouse would be 5(o)F (2.8(o)C) to 2.9(o)F (1.6(o)C) respectively. This level of temperature decrease is such that the minimum temperatures which would occur are well within the acceptable range for a number of horticultural crops. Experimental data confirmed the values obtained by the theoretical analysis. The humidity remained near saturation levels at all times, except when solar energy resulted in a temperature rise of the mine air as it moved through the greenhouse. An engineering analysis was also made of the summer conditions in a greenhouse. This analysis showed that with air change rates of 1/2 to 1 a greenhouse fully cropped would have temperatures 20(o)F (11.1(o)C) to 10(o)F (5.6(o)C) above the mine air temperature.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Kentucky

1.0160,
EVALUATING ENVIRONMENTAL CONDITIONS FOR CURING BURLEY TOBACCO
L.R. Walton, University of Kentucky, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Limestone & Euclid, Lexington, Kentucky* 40506 (KY00145)
OBJECTIVE: Develop and evaluate a model to predict the environmental conditions within tobacco barns during curing. Use the model to evaluate the need for environmental modifiction on tobacco curing barns to minimize adverse effects of weather.
APPROACH: A heat, moisture, and mass balance will be used to develop a three-dimensional-deep-layer-drying analysis of burley tobacco curing within a tobacco barn. The model will include the effects of outside temperature, humidity, windspeed and direction, and solar heating of the roof. Input data needed by the model will be determined from the literature or by experimental observations in curing facilities. The output of the model will be compared to the actual environmental conditions which occurs within a burley curing barn.
PROGRESS: A mathematical model is being developed to predict the temperature and humidity within tobacco barns during curing as a function of ambient temperature, humidity, wind speed, wind direction, and solar radiation. The heart of the model is a two-dimensional deep layer drying analysis which essentially involves expansion of the traditional one-dimensional deep layer drying analysis to account for roof heating during the day. The one dimensional drying equations have been developed and will be tested as a separate component. Experimental data has been gathered from a one dimensional drying arrangement. Preliminary comparisons show that the one dimensional drying equations predict the relative humidity of the air as it moves through the tobacco to within plus or minus 6% r.h. Refinements in this component are necessary. Some parameters may have to be determined experimentally. square grid is being used for the numerical calculations so that wind direction is confined to eight directions (N, NE, E, SE, S, SW, W, and NW). An equation has been proposed to account for roof heating, but has not been evaluated. The model, when completed, will be used to evaluate the need for environmental modification of tobacco curing barns to minimize adverse effects of weather and to show how any modifications can best be accomplished.
SUPPORTED BY Kentucky State Government

1.0161,
CURING BURLEY TOBACCO
W.H. Henson, University of Kentucky, U.S. Dept. of Agriculture Agricultural Engineering Res. Div., Harvesting & Farm Proc Res Br, *Limestone & Euclid, Lexington, Kentucky* 40506 (7809-20190-002)
OBJECTIVE: Determine the response of Burley tobacco to environmental control of temperature, humidity, and air flow during the early stages of drying; to develop economical curing systems with predictable control of leaf color, chemical change, moisture content, and other physical properties; and to develop curing systems which will facilitate mechanization of harvesting and handling.
APPROACH: Consider the complex biochemical changes in the Burley tobacco plant during curing process. Study plant response (color, chemical change, moisture content, gaseous exchange to curing environment (air velocity, temperature, closeness of packing). Determine degree of leaf damage from adverse environmental treatments; determine degree to which adverse affects of environment may be reversed by subsequent environmental treatments.
PROGRESS: A solar curing structure consisting of four forced ventilation curing chambers was used to cure burley tobacco during the Fall 1976. The average daily relative humidity was reduced by a maximum of 5% in the chamber with transmitting roof and the chamber with solar collector--no storage as compared to the conventional chamber. The solar collector- rockbed system supplied enough heat to reduce the relative humidity from the 80 - 90% range to the desired 65 - 70% range for three days of rainy weather. The latter system was superior in the the heat storage enabled it to lower relative humidity during critical rainy periods, thus preventing damage to quality. The temperature and humidity data for all four chambers has been read from the charts and punched on computer cards. The investigation is currently in the first stage of comparison of actual temperatures and relative humidity to the observed data. Work was continued in 1976 to investigate the potential of bulk-curing of burley tobacco for producing a safer cigarette. Thirty-six small curing chambers were employed in testing two varieties, three harvest dates, three curing methods, and six bulk-curing condtions. A total of 323 samples were prepared and submitted for chemical analyses. Three chambers were used to measure sorption and desorption rates of 20-leaf samples. Burn rate and filling value are being measured by newly developed techniques.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Mid Atlantic Area

1.0162,
USING SOLAR ENERGY TO CURE BURLEY TOBACCO
L.R. Walton, University of Kentucky, U.S. Dept. of Agriculture Agricultural Research Service, *Limestone & Euclid, Lexington, Kentucky* 40506 (E(49-26)-1021)
A two-stage solar curing system consisting of solar field curing and curing in a solar barn is being developed. Two days of solar field curing during cool weather was shown to improve the market price of tobacco as much as 0.10 dollars/lb compared to tobacco curing in a conventional curing barn. A solar curing structure consisting of four forced ventilation curing chambers has been evaluated. The objective was to use solar heat to reduce high relative humidity during curing. The chambers were a conventional two-tier chamber with metal roof, one with a fiberglass roof for transmitting solar radiation directly into the chamber, one with a solar collector-no storage, and one with a solar collector and rockbed storage. The latter system was superior in that the heat storage enabled it to lower relative humidity during critical rainy periods, thus preventing damage to quality. The solar collector-rockbed system supplied enough heat to reduce the relative humidity from the 80-90 percent range to the desired 65-70 percent range for three days of rainy weather.
BIBLIOGRAPHIC REFERENCES: Walton, L.R., W.H. Henson, Jr., S.G. McNeill, B.F. Parker, and J.M. Bunn, Solar Curing Facilities for Burley Tobacco, Paper No. 77-3002, presented at the 1977 Annual Meeting of the American Society of Agricultural Engineers, North Carolina State University, Raleigh, NC, June 26-29, 1977.
SUPPORTED BY U.S. Dept. of Energy

1.0163,
DRYABILITY OF HARDWOODS BY SOLAR-HEATED AIR AND ITS RELATIONSHIP TO PERMEABILITY
E.T. Choong, Louisiana State University, Agricultural & Mechanical College, Agricultural Experiment Station, Mcintire Stennis Program, *University Station, Baton Rouge, Louisiana* 70803 (LAB01440)
OBJECTIVE: Determine the effect of steaming on permeability and dryability; Construct and evaluate a small forced-air solar dryer for drying hardwoods; relate climatic and solar energy data to drying of wood in Louisiana; compare the results of solar drying with conventional air and kiln drying, in terms of permeability and dryability; develop technique of accelerating the drying of refractory hardwoods with high temperature by first pre-drying in a solar kiln; review the state-of-the-art of solar energy collection and solar drying for application to wood processing.
APPROACH: Determine effect of steaming on permeability, dryability and shrinkage of several species and wood-types; construct a forced-air solar kiln; compile local climatic data relevant to the solar kiln. Dry several species of wood by kilndrying at high and moderate temperatures,, airdrying, and solar-drying. Drying lumber-size material in a drying charge. Review the state-of-the-art of solar drying.
PROGRESS: Water-saturated longitudinal core samples of 9 hardwoods and 3 softwoods were meas-

ured for specific permeability and for relative permeability to water and nitrogen gas. Constant flow rates were achieved for specific permeability. Relative permeability curve shapes were influenced more by the pore structure of wood than by its specific permeability. It appears that softwoods could be drained much lower in degree of saturation than hardwoods. The permeabilities of sapwood and heartwood of these species were determined using water on never-dried/saturated & on previously dried/resaturated specimens, and nitrogen gas at mean pressure of 2.4 atm and at infinite pressure. Also, their effective permeabilities to water were determined. These specimens were subsequently treated with copper sulfate, and their matched specimens with creosote. The permeability to water was found to be much higher with specimens which had been previously dried/resaturated than with those which had not been dried. High correlations between various permeability and treatability values were obtained. Higher correlations were obtained in hardwoods than in softwoods. Effects of the Klinkenberg equation for gas flow through porous media were determined for a wide variety of wood species. When the results proved negative, a second study was initiated to determine if the cause of the nonconformities could be traced to turbulence.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Louisiana

1.0164,
SOLAR ENERGY AS SUPPLEMENTARY HEAT FOR GRAIN DRYING

M.M. Mayeux, Louisiana State University, Agricultural & Mechanical College, Agricultural Experiment Station, Dept. of Agricultural Engineering, *University Station, Baton Rouge, Louisiana* 70803 (LAB01890)
OBJECTIVE: Accumulate data on locally available solar energy, and determine efficient methods of collecting and storing this energy for optimum use for grain drying. Determine rates of energy storage and retrieving from a medium such as rock or water under various conditions of air flow and develop management techniques for operating a solar dryer.
APPROACH: Data available from the literature and applicable to grain drying will be accumulated. Additional data needed will be developed. A low cost collector will be constructed and tested. Air flow rates will be varied to optimise heat collection. The production of drying potential (C.F.M. of low RH air) will be measured. A storage bed of rock will be evaluated for energy storage and retrieval. Thermal conductivity, specific heat and surface conductance. Coefficient of Louisiana rock will be determined. A small scale collector, energy storage bed and dryer will be built and tested to determine energy production rates needed for designing solar dryers.
PROGRESS: A bed of one (1) to 2 inch rocks four feet deep was subjected to heated air. Temperatures of 110 F, 120 F and 130 F were used with rates of 2/3, 1 1/3, and 2 CFM per lb of rock. A variable temperature input was also used. Temperature distribution at 6 inch intervals with time was recorded. Heat was removed and data was recorded as the rocks were cooled. The time to charge the bed of rock varied from 8 hours at 2/3 CFM per lb. of rock at 110 F, 4 hours at 1 1/3 CFM and 130 F. The time to remove the heat from the bed varied from 6 to 8 hours. At these rates the static pressure varied from 0.068 inches of H(2)O at 2/3 CFM per lb. of rock to 0.250 for 1 1/3 CFM per lb. of rock to 0.519 for 2 CFM lb. of rock. A non-glazed collector was built and partially tested. Air rates of 2.66, 4.0 and 5.34 CFM per square foot of collector were used. The efficiency of the collector was determined and found to vary from 25 percent at 2.66 CFM per square foot to 45 percent at 4.00 CFM per square foot to 60% at 5.33 CFM per square foot. The temperature rise varied from 30 to 40 F.
SUPPORTED BY Louisiana State Government

1.0165,
EVALUATION OF AQUATIC PLANTS AS POTENTIAL FEEDSTUFF FOR DAIRY CATTLE

L.L. Rusoff, Louisiana State University, Agricultural & Mechanical College, Agricultural Experiment Station, Dept. of Dairy Science, *University Station, Baton Rouge, Louisiana* 70803 (LAB01852)
OBJECTIVE: Determine the chemical composition, and cell wall and fiber components of dry water hyacinth for indicating its possible nutritive value. Determine the digestibility of dry water hyacinth ('in-vitro' and 'in-vivo' studies). Determine whether dry water hyacinth would have any palatability problems or harmful effects when fed to dairy animals. Determine the feeding value of dry water hyacinth as a source of protein or a roughage in the ration of growing dairy animals. Determine the feeding value of dry water hyacinth as a source of protein a blended ration or as a roughage in the ration for lactating cows. Determine the feeding value of dry water hyacinth on milk yield and milk composition.
APPROACH: The nutritive value of dry water hyacinth will be evaluated by in-vitro and in-vivo studies. In-vitro cellulose and DM digestibility studies along with chemical analyses will be made. As a source of roughage, NH will be compared with C bermudagrass hay and alfalfa hay in rations for growing dairy heifers and lactating cows; as a source of protein at concentrate portion of the rations. Growth, milk production and composition will be studied.
PROGRESS: Water Hyacinth (E. crassipes) grown in a lagoon, is collected and dried by solar energy at NASA - Bay St. Louis, Miss. Chemical analyses of the solar-dried water hyacinth ranged from 12-16% crude protein, 1.2-1.8% ether-extract, 16.9-19.1% ash, 1.2-1.80% Ca, 0.32-1.64% P, 1.63-1.98% Na, 1.48-2.21% K, less than 0.5% Fe and Mg, and less than 0.1% Mn and Zn. The plant showed an energy value of 3.6 kcal/g, 'in vitro' dry matter digestibility of 58.9% and acid detergent fiber value of 44.23%. The dry plant was palatable to dairy heifers (225kg) when fed as the sole source of roughage along with a grain ration in a preliminary feeding study. This phase is funded by a contract from NASA. Duckweed (family Lemnaceae), a tiny free-floating vascular aquatic plant, is being incorporated in dairy waste lagoons to study its potential for removal of pollutants. Preliminary research on harvesting and utilizing this aquatic plant on a DM basis, duckweed (species - Spirodela polyrhiza and S. oligorrhiza) obtained from the dairy waste lagoon contained a high percentage of protein (35-40%). Chemical analyses of sun (Text Truncated - Exceeds Capacity)
SUPPORTED BY Louisiana State Government

1.0166,
INTEGRATED SINGLE FAMILY OR LIGHT COMMERCIAL SOLAR ASSISTED HEATING SYSTEM USING AIR COLLECTORS MADE FROM PREFABRICATED STEEL (ABBREV)

J. Jordy, Solar Engineering & Equipment Co., *Metairie, Louisiana* 70001 (NAS8-32247)
Development of an integrated single family or light commercial solar assisted heating system using air collectors made from prefabricated steel building materials.
Solar Engineering and Equipment Co., will manufacture and deliver two solar assisted heating systems, one residential and one commercial. Both systems use air heating flat-plate collectors. Methods of applying Tedlar glazings will be developed for these collectors. The single family residential system is located in El Reno, OK, and the commercial system is in Lincoln, NE. System performance is monitored by Marshall Space Flight center. (DOE/CS-0010)
SUPPORTED BY U.S. Dept. of Energy, Office of Conservation & Solar Applications, Div. of Solar Applications

1.0167,
SOLAR HEATING & COOLING DEMONSTRATION - FORT POLK, LOUISIANA

Unknown, U.S. Dept. of Defense, Army, *Fort Polk, Leesville, Louisiana* 71459
OPERATIONAL DATE: April 1977. BUILDING TYPE: Residential, single family 2 units, 1,658 sq. ft. APPLICATION: Heating and Hot water. COLLECTOR TYPE: Liquid flat-plate, (sq. ft.): 256. STORAGE TYPE: WATER, 75 cu.ft.
OBJECTIVE: To compare solar heating of garden apartments, single family houses and rowhouses.
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0168,
THE PASSIVE SOLAR GREENHOUSE HORTICULTURE PROGRAM

K.C. Gray, State Vocational Region 10, *35 Union St., Brunswick, Maine* 04011
The purpose of this project is to plan and build a passive solar greenhouse as part of an ongoing vocational horticulture program. Specific objectives are to: (1) develop and field test an instructional unit which teaches basic solar energy concepts as they apply to greenhouses; (2) develop and field test a four-session adult education program in solar greenhouse construction; and (3) conduct a 2-day workshop on solar greenhouses for State vocational agriculture/horticulture instructors. Maine Vocational Region Ten will contract with the Maine Audubon Society to provide technical assistance in designing a student-built passive solar energy greenhouse as well as a related instructional unit. The greenhouse will be constructed and the unit field tested. These materials will be the basis for the development of a related adult education program as well as a workshop. The knowledge and experience gained will be disseminated by the teacher workshop in May, media coverage, and a final report which will be submitted to appropriate State agencies.
SUPPORTED BY Maine State Government

1.0169,
ENGINEERING SYSTEMS FOR FORAGE CROP PRODUCTION AND USE

R.J. Rowe, University of Maine, Orono Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *36 Winslow Hall, Orono, Maine* 04473 (ME08100)
OBJECTIVE: Improve the engineering and mechanical inputs and models for evaluating alternate forage systems.
APPROACH: Make a detailed engineering analysis of several proposed high capacity continuous flow dryers based in part on previously obtained forage drying data. Verify performance of the most promising approaches on a pilot scale. Develop prediction models of newly proposed and existing drying systems in cooperation with other stations working on a general computer simulation model of forage production systems.
PROGRESS: The pilot scale cross flow dryer was tested at several temperatures covering the planned operating range of 60(0)C to 140(0)C. Some minor modifications were made to minimize air loss at the dryer outlet and to eliminate carry over of particles through the dryer. The small amount of forage available precluded an extensive evaluation of dryer efficiency. The runs obtained were sufficient to establish feed rate settings for subsequent tests. Second cutting alfalfa samples were dried at each of two temperatures, 60(0)C and 140(0)C. Part of each temperature treatment was ground and pelleted. Samples of both ground and pelleted material were forwarded to the Animal Science Department nutritive analysis. A low cost solar air heater 10 ft by 40 ft in area was constructed and used heat ambient air for drying. One batch of second cutting alfalfa was dried over a period of several days using solar heated air. Maximum air temperature observed was 46(0)C. Samples of ground and pelleted forage from this batch were also prepared for nutritive analysis. A series of grinding and pelleting runs were made to determine the best particle size and techniques for pelleting young leafy grass. Five hammer mill sieve sizes between 3/16 and 1/4 inch were used. For the pelleter used a screen size of 1/8 inch seems to be the best compromise between free feeding of the pelleter which is enhanced by small particle size and pellet durability. The standard durability test index using 1/8 inch ground grass was about 90.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Maine

1.0170,
SOLAR ASSISTED HEAT PUMP

N. Smith, University of Maine, Orono Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *36 Winslow Hall, Orono, Maine* 04473
Description: The 'abundant' energies (nuclear, low-grade coal, geothermal, fusion, etc.) do not seem applicable to small scale use-they will not be used directly for powering vehicles or space heating, but will be used through central stations for electric power generation. Other energies (oil from shale, hydrocarbons from remote sites, hydrocarbons from coal, hydrogen, etc.) seem too expensive for anything but vehicle use; hence the bulk of space heating will be forced onto central stations. In the long run this solution will prove difficult if straight resistance heating is used. The cost in both capacity and energy will be high. A single home requiring 15 kw and new stations coming on line at $1,000/kw is a resource allocation hard to manage. The large energy commitment due to the Second Law loss at the central station is another resource management problem difficult to resolve. An immediate and obvious reaction to these twin problems (energy and capacity) is the use of heat pumps for space heating. This solution is satisfactory as long as space heating by heat pump is a small fraction of the system total

load. But if our projections are correct: (1) hydrocarbons become too precious to be consumed for purposes other than transportation, and (2) space heating by heat pumps (topped by resistors in cold weather) becomes the rule; then, an unacceptable load will develop for the central station grid. A possible prototype resolution of this problem is approaching operation at 495 College Avenue, Orono, Maine. The system will work as follows: A heat pump will operate between a 20,000 gal. cold reservoir and a 2,000 gal. hot reservoir. The cold reservoir is to be maintained to at least 50 degrees F by solar collectors. The 20,000 gal. size is based on an analysis of the building heat load and insolation data. Topping resistors will not be used. Solar collectors working at temperature levels of 60 - 70 degrees F are less expensive per unit of energy collected than collectors operating at higher temperatures. A 2,000 gal. hot reservoir will permit the cycle of the heat pump to be interrupted during periods of peak demand on the power grid.

Addenda: Estimated calendar year funding reported as 1974 $20,000, 1975 $25,000. This project is also supported by: Central Maine Power; University of Maine.

SUPPORTED BY U.S. National Science Foundation, Unspecified Unit

1.0171,

ALTERNATE SOURCES OF HEAT ENERGY FOR RURAL MAINE

N. Smith, University of Maine, Orono Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *36 Winslow Hall, Orono, Maine* 04473 (ME08104)

OBJECTIVE: Evaluate the feasibility of new sources of heat energy for domestic, agricultural and industrial use in rural Maine.

APPROACH: Four heat sources will be examined-wood solid combustible waste, waste heat, and solar energy. Evaluations will be made on supply, delivery means, cost per unit, delivered, effluents-apparatus will be developed as needed. Use of heat pumps with low temperature sources and multiple source systems will be evaluated by simulator. Demonstration units for systems which appear feasible will be produced.

PROGRESS: The solar assisted heat pump heated 495 College Avenue for the entire 75-76 winter. 800 sq. ft. of collectors provided 85% of the heat used in the house for the year and 65% of the total heat requirement during January and February. Average COP of the heat pump was 4.6. Collection efficiencies exceeded 50% with ambient/collector temperature differences of 40 F. A single collector module (62 sq.ft.) was tested as a domestic hot water heater during June and July. 110 gallons of insulated hot water storage were provided and 70 gallons were drawn through each day to simulate normal family use. Results indicated the trickling collector is not very useful for collection at elevated temperatures. Approximately 8 lb of water was evaporated each day, maximum storage temperature was only 120 F and collection efficiencies were below 30%. An automated 200,000 BTU/hr wood chip furnace was developed to heat a 7000 sq.ft. laboratory building. Chip feed is by scraper conveyor from a bin with auger metering to the firebox. Firebox temperature approaches 2200 F. The heat exchanger reduces the flue gas to 400 F. The feed auger was jacketed with flue gas for chip drying. condensing heat exchanger then cooled the flue gas to approximately 100 F with the heat gained being used to heat combustion air. Heating efficiencies exceeded 80% with no visible stack emissions. An adaptation of the chip furnace firebox was used to burn poultry litter in an attempt to replace oil for broiler house heating.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Maine

1.0172,

ALTERNATE SOURCES OF HEAT ENERGY FOR RURAL MAINE

N. Smith, University of Maine, Orono Campus, School of Technology, Dept. of Agricultural Engineering, *251 Aubert Hall, Orono, Maine* 04473

Description: As the abundant and less expensive energies such as coal and nuclear appear to be most applicable to central generating stations more 'stationary' needs for energy will probably be converted to use electricity. If straight resistance heating is used the cost in both capacity and energy will be very high. As comfort heating is a low temperature energy user it seems that heat pump units assisted by solar collectors could well fill this need. Providing hot water storage which can be called on by a circulator pump will allow the heat pump units to be kept off peak hours. A research/demonstration unit of this kind is nearing completion in a residential building. Wood provides a convenient and abundant form of stored solar energy but present wood uses waste much of the growth. Research on utilization of wood waste in automated furnaces is underway along with simulation studies to optimize the production from forests through full utilization of photosynthetic material for traditional and fuel uses. An automated research/demonstration furnace of 500,000 BTU/hour output is under construction and a 60,000 BTU/hour unit has been operated for 300 plus hours.

SUPPORTED BY University of Maine

1.0173,

BIOCONVERSION OF SALINE WATER

G.V. Levin, Biospherics Inc., *4928 Wyaconda Rd., Rockville, Maryland* 20853 (AER77-19732)

Conversion of saline water by distillation, reverse osmosis or electrodialysis has proved to be uneconomic. One of the main reasons for this is the cost of providing the energy for the system. It is proposed that a new and simpler system be developed, based on the ion exchange properties of algae. The algae would be induced to take up the salt from the saline water, making use of solar energy. They would then be transferred to a holding basin, in which they would be induced to give up the salt. The algae would be recycled, and surplus algae could be used as a source of protein. The research is designed to resolve the key question of whether or not algae can indeed be induced to take up and release sodium chloride in a controlled fashion.

SUPPORTED BY U.S. National Science Foundation, Div. of Advanced Energy & Resources Research & Technology

1.0174,

STRUCTURES AND RELATED EQUIPMENT FOR CONTROL OF PLANT ENVIRONMENT

W.A. Bailey, U.S. Dept. of Agriculture, Agricultural Research Service, Agricultural Engineering Research Div., Livestock Eng Farm Stru Res Br, *Beltsville, Maryland* 20705 (1109-12051-002)

OBJECTIVE: Develop design criteria for structures and related equipment for controlling plant environments for research and for commercial production.

APPROACH: Air and soil environmental factors such as light, temperature, moisture, and carbon dioxide will be related to greenhouse plant growth design. Performance criteria will be determined, using selected experimental plants. Modern laboratory instruments, such as computer-controller units, will be adapted for measuring plant growth and measuring and controlling environmental variables for plants. New materials, shapes and construction methods for greenhouse and plant growth chambers will be evaluated.

PROGRESS: An extensive review of literature was started and completed on the applications of solar energy to agriculture, specifically greenhouses. No references were found that indicated that a complete research program for maximizing all aspects of solar energy use in greenhouse production of plants was underway. Tomato seedlings, grown in a growth chamber with 1000 ppm CO(2) for the third week of a three-week growing period, were significantly larger than seedlings grown in 400 ppm CO(2) during the third week, regardless of CO(2) level during the first and second weeks. Seedlings started in 1000 ppm CO(2) during the first week, then moved to the greenhouse for two weeks, were as large as seedlings kept in the growth chamber for three weeks, except those given 1000 ppm CO(2) during the third week. Petunia seedlings grown in 1000 ppm CO(2) during all three weeks were nearly twice as large as plants grown in high CO(2) for 0, 1, or 2 weeks. There were no differences among the latter, but they were 2 to 4 times as large as plants grown in the chamber at 1000 ppm CO(2) for the first week, then in the greenhouse for two weeks. Petunias grown in 1000 ppm CO(2) for weeks were 40 times larger than those grown in the greenhouse. Work was initiated to determined how environmental factors affected growing tissue culture inside of a flask. A refrigeration system was designed and built to control the temperature of the shelf on which the flasks were placed.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Beltsville Agricultural Research Center

1.0175,

DEVELOPMENT OF RURAL AND REMOTE APPLICATIONS OF WIND GENERATED ENERGY

L.A. Liljedahl, U.S. Dept. of Agriculture, Agricultural Research Service, Agricultural Engineering Research Div., *Beltsville, Maryland* 20705 (E(49-26)-1026)

The program objective is to identify, develop and test agricultural applications of wind systems. Work is organized under two main areas: (1) general studies, including studies of the feasibility of using small WECS for rural electrical generation, fertilizer production, agricultural fuel production and in small multiple-unit applications; and (2) specific tests of such applications as irrigation, space heating and ventilation, and agricultural products processing and storage. Current projects include tests of dairy milk cooling (Kaman Sciences Corp.) and direct hydraulic conversion to heat (Cornell Univ.). New projects include tests of refrigeration-based grain drying, poultry manure drying and apple storage cooling. (ERDA-77-32)

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0176,

SOLAR ENERGY FOR MILKING PARLOR HEATING AND COOLING

P.D. Thompson, U.S. Dept. of Agriculture, Agricultural Research Service, Animal Physiology & Genetics Inst., Genetics & Management Lab., *Bldg. 173, Romm 209, Beltsville, Maryland* 20705 (1106-20401-001)

OBJECTIVE: Develop technology and demonstrate the feasibility of using waste heat recovery, load reduction, and solar energy to reduce the electrical and fossil fuel requirements for operation of milking parlors for dairy production.

APPROACH: Solar energy collectors will be specified, procured or constructed, and installed on appropriately modified structures for capture of heat energy. Insulated hot water storage tanks will be constructed to store this energy over diurnal and short-term climatic cycles. Additional heat will be recovered by scavenging waste heat from refrigeration compressors and vacuum pumps. The heat energy thus obtained will be used to reduced the electrical energy required for water and space heating and for milk cooling. Non-thermal load reduction will be achieved by developing lighting and milking systems of improved efficiency. System flexibility will be sufficient to accept heat or mechanical energy from wind power if such a project is subsequently established at this location.

PROGRESS: An operating solar heating system has been constructed in the milking parlor at the Beltsville Agricultural Research Center. Approximately 20 square meters each of four types of flat-plate solar collectors are used. The types are: open-channel, non-selective, single glazed; closed channel, non-selective, double glazed; closed channel, selective, single-glazed; and closed channel, selective, double glazed. Heat storage is a 37,000 liter insulated concrete in-ground tank. Heat is used for domestic water pre-heating by a tube-in-shell heat exchanger and for milking pit space heating by floor-mounted plate heaters. Each heat source and heat using device is monitored by thermocouples and flow meters. Data is automatically collected, linearized, integrated, and stored by a programmable calculator which controls and reads a scanner and digital multimeter. The circulating fluid is corrosion-inhibited water. Aluminum collectors are further protected from corrosion by passing their supply water through a packed column of aluminum wool. The system began operation in spring of 1976 and has run continuously since. About one half of the heat energy demand of the targeted loads in the milking parlor is now being supplied by solar heat. (4 x 108 J/day). Major problems have been large heat losses from the storage tank, freezing of some circulation (Text Truncated - Exceeds Capacity)

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Beltsville Agricultural Research Center

1.0177,

PRINCIPLES OF CONTROLLED ENVIRONMENT PRODUCTION OF CROPS IN SOLAR ENERGY SUPPLEMENTED GREENHOUSES

R.C. Liu, U.S. Dept. of Agriculture, Agricultural Research Service, Plant Physiology Inst., Light & Plant Growth Lab., *Bldg. 046A, Beltsville, Maryland* 20705 (1109-20191-001)

OBJECTIVE: Obtain information on physical and biological components of a solar powered greenhouse for establishing technical and economical feasibility. Design, construct, test and demonstrate a greenhouse module that uses solar cooling and heating.

APPROACH: Review and compile relevant literature and data in consultation with Federal-State solar energy R/D institutions, solar energy meetings and workshops. Analyze information, synthesize plans, and design a solar greenhouse module. Construct a solar greenhouse module, consisting of collectors, storage and distribution units, and controls. The system will be evaluated in two existing glasshouses at BARC and new modules specifically designed for solar energy. Cooling will be used initially to reduce relative humidity and increase the efficiency of wet pads.

PROGRESS: A project to investigate the feasibility of selective transmission of PAR and rejection or collection of IR is in progress. search for materials has been initiated. To date no solid materials other than interference filters have been found which will absorb or selectively reflect radiation beyond PAR (400-700nm) into infrared range up to 1000-1500 nm. However, a 5% copper sulfate solution in a 1 cm path cuts off at 725 nm. Varying the concentration and path depth may produce the desired spectral environment of PAR and IR separation. Tomato plants were grown in a controlled environment chamber in which light quantity and quality varied continuously. Three light sources provided energy in the ranges 400-500, 500-600, 600-700 nm Blue, Green, and Red, respectively. Dry weight (mg) was described by the relationship, DW = -311 5.12B 5.25G 4.95R 46.4T(emperature) -.012BG - .010BR. For internode length the relationship is: INL = 3635 2.06B 4.01G 4.71R - 31.6T - .017BG .006BR - .019GR. Energy levels were high enough to produce plants that flowered. Photomorphogenic responses, internode length, were as would be expected from exposure to blue and red light; however, significant interaction indicates other than linear effects of the individual lights.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Beltsville Agricultural Research Center

1.0178,

SOLAR HEATING & COOLING DEMONSTRATION - ANDREWS AIR FORCE BASE, MARYLAND

Unknown, U.S. Dept. of Defense, Air Force, *Andrews Air Force Base, Maryland* 20331

OPERATIONAL DATE: April 1977. BUILDING TYPE: Residential, single family, 1487 sq.ft. APPLICATION: Heating and Hot water. COLLECTOR TYPE: Liquid flat-plate, (sq. ft.): 672. STORAGE TYPE: WATER, 133 cu.ft.

OBJECTIVE: To compare systems: liquid, air and higher performance collectors in a temperate climate.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0179,

SOLAR HEATING & COOLING DEMONSTRATION - ANDREWS AIR FORCE BASE, MARYLAND

Unknown, U.S. Dept. of Defense, Air Force, *Andrews Air Force Base, Maryland* 20331

OPERATIONAL DATE: April 1977. BUILDING TYPE: Residential, single family 2 units, 1487 sq.ft. APPLICATION: Heating and Hot water. COLLECTOR TYPE: Air flat-plate, (sq. ft.): 624. STORAGE TYPE: Rock, 347 sq.ft.

OBJECTIVE: To compare systems: liquid, air and higher performance collectors in a temperate climate.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0180,

SOLAR HEATING & COOLING DEMONSTRATION - ANDREWS AIR FORCE BASE, MARYLAND

Unknown, U.S. Dept. of Defense, Air Force, *Andrews Air Force Base, Maryland* 20331

OPERATIONAL DATE: April 1977. BUILDING TYPE: Residential, single family 1487 sq.ft. APPLICATION: Heating and Hot water. COLLECTOR TYPE: Evacuated tube, (sq. ft.): 576. STORAGE TYPE: Water, 133 sq.ft.

OBJECTIVE: To compare systems: liquid, air and higher performance collectors in a temperate climate.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0181,

FEASIBILITY OF UTILIZING SOLAR ENERGY IN COMMERCIAL BROILER PRODUCTION

J.L. Cain, University of Maryland, College Park Campus, Agricultural Experiment Station, Dept. of Agricultural & Resource Econ, *College Park, Maryland* 20740 (7097-20400-008-A1)

OBJECTIVE: Evaluate the feasibility of solar energy collection, storage, and use in broiler chicken production, determine the reduction in conventional energy use to be expected from solar energy use, and to determine physiological effects on broiler chickens from use of solar energy.

APPROACH: Solar heating systems, designed specifically for poultry brooding and rearing, will be economically evaluated, and the best overall system will be installed on experimental rearing facilities. Trials will be conducted comparing the solar-heated facility with a comparable conventionally heated facility. Data on reduction in fuel use resulting from use of solar energy, and performance of broiler chickens will be collected, analyzed, and summarized.

PROGRESS: A solar energy collection, storage and distribution system for use in broiler chicken production has been constructed and installed on one of the test chambers in the University of Maryland's Environmental Research Broiler Facilities at Salisbury, Maryland. Data to determine reduction in conventional energy use and physiological effects on broiler chickens from solar energy use are being collected and evaluated.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Alabama - North Mississippi Area

1.0182,

FEASIBILITY OF UTILIZING SOLAR ENERGY IN COMMERCIAL BROILER PRODUCTION

J.L. Cain, University of Maryland, College Park Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *College Park, Maryland* 20740 (MD-RAM-49)

OBJECTIVE: Design and install a solar collector and heat storage system on one of the test chambers in the Environmental Research Broiler Facilities at Salisbury, Maryland. Determine the conventional fuel savings of this chamber over one of the other chambers in the facility. Check physiological responses of broilers that may be contributed to the solar system.

APPROACH: A solar collection and storage system will be designed and installed on one of the nine 1000-bird environmental chambers at the Broiler Sub-station of the Maryland Agricultural Experiment Station near Salisbury, Maryland. Research will be conducted to: determine the conventional fuel savings by use of a solar system and check physiological responses of the broilers that may be contributed to the solar system.

PROGRESS: An air-collection water-storage solar-system was constructed at the University Environmental Broiler Research Facilities near Salisbury, Maryland. One 20-foot by 40 foot chamber was equipped with hot water convectors to transfer energy from the heated water in storage to the air of the research chamber. A forty-point data acquisition system with a magnetic tape unit is used for recording temperature of air and water throughout the system. Following the initial trial period of the system several modifications were made. Results of the fall flock of 1976 gave promising results. Day old chicks were placed October 12 using limited-area brooding in the solar-heated chamber and full-area brooding in a conventionally heated chamber. The limited-area had a bird density of 0.26 ft /bird from 0-2 weeks; 0.51 ft /bird from 2-4 weeks, and 0.8 ft /bird from 4-8 weeks. The full-area brooding had a density of 0.8 ft /bird from 0-8 weeks. An electric heater was used to supply supplemental heat to the solar-energy heated chamber, whereas, LP Gas was used in the full-area brooding chamber. The energy, in BTU's required to heat the two chambers, excluding solar energy was 812,294 BTU's for the solar-heated limited-area brooding chamber.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Maryland

1.0183,

ASSESSMENT OF SOLAR ENERGY APPLICATION IN AGRICULTURE

A.M. Cowan, University of Maryland, College Park Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *College Park, Maryland* 20740 (0709-15701-001-G)

OBJECTIVE: Assess present agricultural operations to determine those with potential for use with solar energy, define and quantify cost/effectiveness and the potential saving of petroleum energy through the application of solar energy, to recommend an overall experimental research program to establish the technical and economic feasibility of using solar energy in agricultural production and processing, and to recommend strategies for achieving adoption of these practices found practical.

APPROACH: Questions, interviews, conferences, and literature search techniques are to be used to assemble pertinent information. Judgemental evaluation, mathematical programming, and other methodology will be used in the identification and development of recommended programs.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Beltsville Agricultural Research Center

1.0184,

ASSIST THE NATO COMMITTEE ON THE CHALLENGES OF MODERN SOCIETY (CCMS) SOLAR HEATING AND COOLING OF BUILDINGS PROJECT

R. Allen, University of Maryland, College Park Campus, School of Engineering, Dept. of Mech Engin, *College Park, Maryland* 20742 (E(40-1)-4908)

The United States is the pilot country for the Solar Energy Pilot Study of the Committee on the Challenges of Modern Society (CCMS) of NATO. The objective of this pilot study is the exchange of information on solar heating and cooling programs and projects of each participating country so as to encourage the cost-effective and practical application of solar energy to heating and cooling in residential, commercial, agricultural, and public buildings.

The key elements in this information exchange are the preparation and distribution of special reports, prepared in an agreed format, and general reports concerned with solar heating and cooling in buildings, and the participation in meetings for the review of research programs and exchange of information and ideas. The objective of this work is to provide program support to ERDA in its role as the lead agency for this CCMS Pilot Study.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0185,

INTEGRATED SINGLE FAMILY SOLAR HEATING HOT WATER SYSTEM USING AIR COLLECTORS, AIR/WATER HEAT EXCHANGERS, WATER TANK STORAGE (ABBREV)

R. Meyers, Fern Engineering Inc., *Bourne, Massachusetts* 02532 (NAS8-32246)

Development of an integrated single family solar heating and hot water system using air collectors, air/water heat exchanges, water tank storage, and integral air handler.

Fern Engineering, Inc., will develop, manufacture, and deliver two single family solar assisted heating and hot water systems to two sites. The systems consist of air heating flat-plate collectors using a dual air path from the collector. The collector uses a textured copper foil absorber with a black chrome selective coating. The site locations are Lansing, MI. and Tunkhannok, PA. Marshall Space Flight Center will monitor equipment performance. (DOE/CS-0010)

SUPPORTED BY U.S. Dept. of Energy, Office of Conservation & Solar Applications, Div. of Solar Applications

1.0186,

ASSESSMENT OF A SEMI-CLOSED, RENEWABLE RESOURCE-BASED AQUICULTURE SYSTEM

J.H. Todd, New Alchemy Inst., *P.O. Box 432, Woods Hole, Massachusetts* 02543

This award provides for incremental funding for the NSF continued grant OPA 77-16790A01. The objective of the overall award is to model and assess the ecological and economic characteristics of a semi-closed aquaculture production system based on passive solar energy and nutrient and waste recycling. The research project will determine the factors which limit solar-based aquaculture and assess the potential of integrating solar, structural, and ecological concepts in semi-closed fish culture systems. To accomplish this, the project team is investigating the relationships between population densities, rates of external feeding and indigenous metabolities, and natural oscillations in light and thermal conditions. Research for this period of the award will focus on further developing the model of the ecology of the system to a simulation stage and experimentation with the system to evaluate the effects of density, number of species, design of the fish pond system, and feeding regimes.

SUPPORTED BY U.S. National Science Foundation, Office of Problem Analysis

1.0187,

IMPLICATIONS OF DEMAND, STRUCTURE AND ENERGY CHANGES FOR THE N.E. BROILER AND EGG INDUSTRIES

R.L. Christensen, University of Massachusetts, Amherst Campus, Agricultural Experiment Station, Dept. of Food & Resource Economics, *Amherst, Massachusetts* 01002 (MAS00393)

OBJECTIVE: To estimate the energy use and the implications of high cost energy to the production and marketing of broilers and eggs.

APPROACH: Energy input-output parameters will be estimated for broiler and egg operations in the northest using budgeting techniques. Alternative production and marketing systems will be identified and compared with respect to energy use. Alternative energy sources will be examined and evaluated with respect to cost and efficiency. Energy costs will be placed in the context of cost of production and competitive position.

PROGRESS: Energy use estimates for the broiler and egg producing sectors have been developed for the six New England states. Energy requirements for brooding, raising replacement birds, broiler growing, and laying flock maintenance were obtained from secondary data. Representative farm units have been developed with energy requirements for conventional technologies. Energy conserving technologies are described and impacts on energy use and costs are specified. In addition, the solar energy alternative will be analyzed with respect to applicability and economic feasibility. Aggregation procedures will be employed to derive estimates of regional impacts under varying assumptions concerning rate of adoption.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Massachusetts

1.0188,

SOLAR ENERGY FOR GREENHOUSE HEATING

W.A. Feder, University of Massachusetts, Amherst Campus, Suburban Experiment Station, Suburban Exper Station, *240 Beaver St., Waltham, Massachusetts* 02154 (MAS00429)

OBJECTIVE: This is a joint effort of Federal agencies (ERDA, USDA) State agencies (Agr. Exper. Stn.) and private industry to determine and demonstrate the practical feasibility of growing commercially important plant materials in a greenhouse heated by solar energy systems.

APPROACH: A commercial greenhouse will be retrofitted with solar energy heating units. Data will be collected and analyzed on environmental conditions, energy ratios, collection, distribution and consumption, foliage plant productivity and quality.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Massachusetts

1.0189,

AN OPTICAL TRAP FOR THE USE OF DIFFUSE SOLAR RADIATION IN HYPERTHERMAL AQUACULTURE

W.S. Vonarx, Woods Hole Oceanographic Inst., Dept. of Oceanography, *Main St., Woods Hole, Massachusetts* 02543

OBJECTIVE: The object of the proposed experiment is to collect sunlight on open water surfaces and trap the energy through a combination of absorption on a blackened pond floor and total reflection at the free surface and an artificially enhanced pycnocline. Both the direct beam and diffuse radiation from the sun suffer refraction toward the normal when the ray paths intersect a medium of higher refractive index. It is proposed to steepen this (trap) angle as much as is practicable in a relatively shallow (1-meter deep) pond having a very dense layer of (waste) brine, so dense that convection cannot penetrate the pycnocline, overlain by an insulating (infrared opaque) layer of fresh water.

R. M. Bloch, Director of the Dead Sea Works, Ltd. proposed this method of solar energy conversion in 1960 and H. Tabor, Director of the National Physical Laboratory of Israel directed some preliminary experiments. H. Weinberger calculated a peak temperature of 128 degrees C. Experimental peaks of 92 degrees C have been achieved.

HOW INFORMATION WILL BE APPLIED: Low-grade heat is useful for space heating and air conditioning and, if it can be produced cheaply enough, may become an integral provision of architectural design. Similarly the need for low-grade heat and power for mechanical operations is a basic need and (at present) a heavy expense in sewage treatment and aquaculture. With large quantities of low-grade heat available for direct heating and the use of Rankine cycle engines for mechanical power production it may be possible to employ solar heat and power as a means for reducing, or possibly even eliminating, the cost of these requirements in sanitary engineering and aquacultural systems designs.

ACCOMPLISHMENTS DURING PAST TWELVE MONTHS: 1. Measurements of the mean annual solar (direct and diffuse) flux for the latitudes of New England have been made during 1974-76. 2. Sufficient heat has been collected for the operation of a 3m x 8m greenhouse in the coldest months without the use of fuels or electrical equipment other than a small pump driven by wind-generated electricity. 3. An intensive study of world power demand has been made and compared with the solar-terrestrial heat balance which indicates the climatologically safe upper limit of power production by man and the methods available in nature by which both present (Text Truncated - Exceeds Capacity)

SUPPORTED BY U.S. Dept. of Commerce, National Oceanic & Atmospheric Admin., Sea Grant Office

1.0190,

FEASIBILITY OF SOLAR WATER HEATING IN FOOD PROCESSING PLANTS IN MIDWEST

F.W. BakkerArkema, Michigan State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *New Administration Bldg., East Lansing, Michigan* 48823 (12-14-7001-901)

The project objectives are to: design and build solar water heating system for milk processing plant; conduct experiments using different collectors, flow rates and conditions; and determine specific solar hot water system requirements for midwestern milk, meat, and vegetable and fruit processing plants. The approach is to: design solar water heating system for MSU milk plant; develop arrangement and sizing of components for possible future expansion; test and modify system using solar water heating system as integral part of the dairy plant; and following preliminary experiments, develop recommendations for use of solar heat augmentation in midwestern dairy operations.

SUPPORTED BY U.S. Dept. of Energy, Office of Conservation & Solar Applications, Div. of Solar Applications

1.0191,

MATHEMATICAL MODELING OF SOLAR GRAIN DRYING

F.W. BakkerArkema, Michigan State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *New Administration Bldg., East Lansing, Michigan* 48823 (3090-15704-012-A)

OBJECTIVE: Determine the economic and technical feasibility of using solar energy to supplement or replace other fuels in drying grain.

APPROACH: Determine probability of success of drying corn with solar energy under specified conditions using Michigan State University drying model and appropriate input data. Determine range of conditions where the MSU drying model based on thin layer drying equation is more accurate and efficient than the equilibrium model now widely used.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Kansas - Nebraska Area

1.0192,

FEASIBILITY OF SOLAR WATER HEATING IN FOOD PROCESSING PLANTS

F.W. BakkerArkema, Michigan State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *New Administration Bldg., East Lansing, Michigan* 48823 (7094-20510-010-A)

OBJECTIVE: Survey hot water usage and needs in midwestern food industries; determine economics and potential fuel savings by use of solar energy; determine feasibility of solar water heating applicability in midwestern climate.

APPROACH: Survey hot water uses, temperatures and schedules in three midwestern food processing plants (meat, dairy, fruit and vegetable). Study three sizes (S,M,L). Simulate solar water heating available from midwestern climates conditions, determine auxiliary heat necessary, if any. If favorable, design solar water heater for a milk processing plant.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Florida - Antilles Area

1.0193,

ENERGY AND AGRICULTURE

F.W. BakkerArkema, Michigan State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *New Administration Bldg., East Lansing, Michigan* 48823 (MICL01208)

OBJECTIVE: Find ways to beneficially use waste heat from electric power plants in agriculture. The uniqueness of the MSU research does not lie in the subject of the study, but in the approach. Rather than considering the utilization of waste heat in one or two agricultural processes on an experimental basis, the feasibility of an integrated system of a significant number of subsystems is being examined by systems analysis techniques. The result of this research effort should be an analytical tool that can be used to analyze the feasibility of using waste heat from power plants in agriculture.

APPROACH: An optimization technique for determining the best combination of agricultural subsystems for a power plant is being developed. The program has already been used to determine the effect of weather conditions on the best mix of a power plant-fish pond-soil pipe system. During the second year of the project additional subsystems will be modeled and economically investigated. Greenhouse culture, waste treatment and grain drying offer possibilities. Ownership options and financing schemes have to be considered along with the transportation of the waste heat from the power plant to the different subsystems.

PROGRESS: The subject of energy and agriculture was studied in the areas of solar grain drying, solar water heating, greenhouse heating and energy conservation in grain dryer design. The main results are: Shelled corn can be partially dried with natural air in Michigan as well as by the use of solar collectors. Solar water heating can be practiced in Michigan. A greenhouse heat balance model has been developed. Concurrent flow driers fitted with heat pipe exchangers save up to 50% of the energy required by conventional crossflow driers.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Michigan

1.0194,

ANIMAL HOUSING ENVIRONMENT

M.L. Esmay, Michigan State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *New Administration Bldg., East Lansing, Michigan* 48823 (MICL00981)

OBJECTIVE: Develop and verify design criteria for control of the thermal environment for swine production.

APPROACH: Develop adequate information for prediction of air flow patterns, jet stream velocities, air entrainment, thermal mixing, air stratification, moisture diffusion and air management in general for design of precise ventilation systems. Air flow patterns will be studied in a 1/4 scale model and full

scale buildings. Air flow rates and slot inlet design and location will be varied. Both theoretical and empirical approaches to the problem will be made.

PROGRESS: Work continued on the development of a computerized simulation systems model of the in-house manure drying capabilities of ventilation air exchange for cage-type poultry houses. A paper was presented at the National ASAE meeting and a doctoral dissertation is being prepared on the subject by John Dixon. High feed prices have caused egg producers to want laying house temperatures of up to 70 F in order to maximize feed conversion efficiency. This higher temperature level of 70 F, as compared to about 50 F during the past few years, has been found to be difficult to attain without supplemental heat even with better insulated and higher density houses. The maximizing of in-house manure drying detracts from the possibility of attaining the higher house temperature as more of the available bird heat is used for evaporating water. A project proposal was made and $32,000 was approved from ERDA, through CSRS/USDA to start research July 1, 1976 on the utilization of solar energy for the supplemental heating of cage-type laying houses. A 1200 sq. ft. solar collector was constructed although it was not operational during 1976. The collector is made of conventional building materials. It is glass covered and designed for using air as the medium to carry the solar energy from the collector into the poultry house. Studying the control of the environment in calf housing with two experimental chambers. The control of humidity and thus diseases is critical.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Michigan

1.0195,

SUPPLEMENTAL HEATING OF LAYING HEN HOUSES AND EXCRETA DRYING IN THE NORTHERN STATES WITH SOLAR ENERGY

M.L. Esmay, Michigan State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *New Administration Bldg., East Lansing, Michigan* 48823 (7091-20401-011-(AG))

OBJECTIVE: Develop and evaluate techniques for use of solar energy for supplemental heating of cage-type egg production houses in the northern states in winter, and for drying of poultry excreta produced in such houses in both summer and winter.

APPROACH: Solar energy collection system will be installed on caged layer research house to increase winter environmental temperature in house from 55 to 70 F. in order to reduce feed consumption, reduce ammonia and moisture in house, and enhance drying of manure. Solar system will be used in summer to increase drying of manure produced in houses.

PROGRESS: A 1200 ft flat plate, single air pass solar collector has been designed and constructed for providing supplemental heat to a 5000 laying hen, cage-type poultry house. The collector is of simple design. Conventional farm building materials have been used., such as poles, dimension lumber, plywood, aluminum roofing and glass. The collector is first being evaluated without storage. The solar energy is introduced into the ventilation air system of the poultry house as available. Additional in-house excreta drying will be provided when the additional supplemental heat is supplied and hopefully a more uniform 70 F. environmental temperature can be maintained in the house. This has not been evaluated as yet.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Alabama - North Mississippi Area

1.0196,

ANIMAL WASTE MANAGEMENT SYSTEMS FOR THE 1980'S

H.C. Zindel, Michigan State University, Agricultural Experiment Station, Dept. of Poultry Science, *New Administration Bldg., East Lansing, Michigan* 48823 (MICL01064)

OBJECTIVE: Develop optimal animal manure management systems to meet evolving environmental and economic requirements and be compatible with increasing needs for animal protein. Characterize atmospheric contaminants and develop abatement methods to eliminate contaminants potentially harmful effects on human and animal health. Investigate use of by-products of animal manure management systems for energy sources, feed ingredients, plant nutrients for crop production and other potential uses. Characterize non-point population water runoff sources from livestock and poultry enterprises on pasture production systems and land areas with manure application and further develop guidelines for abatement of non-point pollution sources from animal manures.

APPROACH: Waste management systems presently employed in Michigan will be monitored and evaluated for improved design for machinery management technique and collection alleyways. Determine the influence of feeding an odor suppressant to broilers and laying hens in relationship to feed efficiency, weight gain, and fecal odors. Study of anaerobic organisms in poultry anaphage. Upgrading the crude protein of anaphage. Study the calcium and postasium availability from poultry anaphage. Study the amino acid availability by employing turn-over rate estimates, involving radio labeled amino acids.

PROGRESS: The in-house drying system was designed to reduce layer excreta moisture before final dehydration with a manure dryer. This particular design consisted of a forced exhaust system in the cage area and wind tunnel for drying excreta on a conveyor belt leading to the dryer. Excreta samples were taken from under the cages, in the pit, and on the conveyor belt during the 24 hours of in-house drying. The results showed that the 73-74% moisture of fresh layer excreta was reduced to 59% moisture during this drying process. This system can be recommended for the practical commercial operation to reduce manure dehydration cost and minimize the laying house odor. Utilization of solar energy for supplemental heating of cage-type laying houses during cold weather is being investigated. The use of solar heat to maximize in-house drying of excreta is also being evaluated.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Michigan

1.0197,

SOLAR ENERGY - GRAIN DRYING AND WATER HEATING

F.W. BakkerArkema, Michigan State University, School of Agriculture & Natural Resources, Dept. of Agricultural Engineering, *Soil Science Bldg., East Lansing, Michigan* 48823

The solar drying study of grain consisted of an experimental and feasibility study. The results indicated that solar grain drying was not economical in the states of Michigan and Missouri. The solar water heating study for the warming of water in milk-, fruit-vegetable, and meat processing plants is still in progress. Results of the first year indicate that solar water heating can replace conventional fossil fuel water heaters economically for about 20 to 50%, depending on the type and size of the plants.

SUPPORTED BY U.S. Dept. of Energy

1.0198,

SOLAR ENERGY TRANSDUCTION BY PHOTOELECTRIC LIPID MEMBRANES

H.T. Tien, Michigan State University, School of Natural Sciences, Dept. of Biophysics, *243 Natural Resources Bldg., East Lansing, Michigan* 48824

DESCRIPTION: Ultrathin lipid membranes less than 100 A thick separating two aqueous solutions have been widely used models of biological membranes. Recent experiments using these membranes which contain photosynthetic pigments or dyes have demonstrated that, upon illumination, an emf and a current can be generated. This project is concerned with the research and development of pigmented lipid membranes (termed photoelectric lipid membranes) into a practical device for converting solar energy to electricity. In this description, a brief review of the scientific background of photosynthesis by the green plant is presented, in which mechanisms for the conversion of solar energy based on solid-state physics are discussed. The connection between the photoelectric lipid membrane and photosynthetic thylakoid membranes and the rationale for the proposed study are stated in some detail. The principal short-range goal of the proposed study is to establish the scientific and technical feasibility of using pigmented photoelectric lipid membranes as a solar energy transduction system for the purpose of generating electricity. It seems highly likely that the initial phase of work can be achieved within three years. When scientific and technical viability of the system is indicated, the long-range goal is to construct a prototype system and test it under simulated and actual environmental operating conditions. A key feature of the proposed work is to investigate in detail an alternative photovoltaic system not based on the unusual solid-state devices such as silicon and Cu(2)S-CdS solar cells.

SUPPORTED BY Michigan State University

1.0199,

MULTI-STATE MIDWEST SOLAR ENERGY CONFERENCE

D.N. Smith, University of Michigan, Ann Arbor Campus, School of Literature Science & the Arts, Dept. of Zoology, *Ann Arbor, Michigan* 48104 (EG-77-C-02-4360.A000)

Department of Energy contract was to help support a Solar Energy Conference to survey the current solar energy technology and to describe successful applications of this technology to attendees at a midwest regional conference. The applications covered cooling of homes, industrial, commercial and educational builldings and heat for industrial and food processing. Dept. of Commerce, EDA: This support was to develop a preliminary feasibility of the economic development potentials arising from an anticipated rapid expansion of aluminum in automotive applications. National Science Foundation funding was to bring together academic and industry leaders in a workshop to analyze the research problems in industrial productivity.

SUPPORTED BY U.S. Dept. of Energy

1.0200,

SOLAR ENERGY USING A HYBRID SOLAR SYSTEM

P. Pfister, Architectural Alliance, *400 Clifton Ave. S., Minneapolis, Minnesota* 55403 (EG-77-G-04-4146)

The purpose of this project is to design and construct a single family residence that uses passively collected solar energy for a significant portion of its space heating requirements. The building will be in the Minneapolis metropolitan area, an area that has a high winter heating load, average to above average winter sunshine, and periods of relatively warm summer weather. Upon completion of the residence a number of ways to store and control low temperature heat will be tested, and data will be collected. (DOE/CS-0010)

SUPPORTED BY U.S. Dept. of Energy, Office of Conservation & Solar Applications, Div. of Solar Applications

1.0201,

ALTERNATIVE ENERGY SYSTEMS FOR PROTOTYPE OFFICE BUILDING OF THE GIRL SCOUT COUNCIL OF ST. CROIX VALLEY

T.D. Childs, Girl Scout Council of St. Croix Valley, *St. Paul, Minnesota*

This project will incorporate all feasible and applicable new energy systems in this office building. It would incorporate all the energy-conserving systems now available, as well as a solar energy system for heat and hot water, a cold storage cooling system, a wind generator for electricity, and a clivus multrum sewage system. A greenhouse would be used to purify the air and utilize the compost.

SUPPORTED BY Minnesota State Government

1.0202,

SOLAR HEATING & COOLING DEMONSTRATION - BLOOMINGTON, MINNESOTA

Unknown, Marvin Anderson Co., *Bloomington, Minnesota*

The project involves the application of a solar heating and domestic hot water preheating system to a single family detached dwelling. The wood frame two-story house has 1,215 square feet of heated floor area. Collectors are mounted on the steep south-sloping roof. Heat loss is reduced by the addition of more insulation in the walls, floors, and ceiling.

SOLAR APPLICATION: HEATING AND HOT WATER

COLLECTOR: 378 square feet liquid-cooled flat-plate manufactured by Lennox Industries.

STORAGE: 1,000 gallons of liquid within an insulated fiberglass tank located in the basement. Heat removed from the collectors passes through a heat exchange in the storage tank.

DISTRIBUTION: Forced air. A heating coil in the primary supply duct warms air circulated past the coil for distribution by ducts to the living spaces.

AUXILIARY ENERGY SYSTEM: Gas-fired furnace. The furnace provides total or supplemental energy to a heat exchanger in the ductwork placed after the fan.

DOMESTIC HOT WATER SYSTEM: The domestic hot water supply is preheated in a 64 gallon stone-lined tank. Heated water from storage circulating through a finned copper heating coil. The preheat

tanks supplies a 50 gallon conventional water heater.
COOLING: Natural ventilation.
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0203,
COMBINED HEAT AND MASS TRANSFER WITH PHASE CHANGE IN POROUS MEDIA
E.R. Eckert, University of Minnesota, Minneapolis Campus, School of Engineering, Dept. of Mech Engin, *105 Morrill Hall, Minneapolis, Minnesota* 55455
In the effort to conserve energy it has been proposed to use the ground as energy source, sink, or store, for instance to insulate buildings from the variable atmospheric temperature by locating them underground, to store energy in the ground for reuse in buildings, to use waste heat from power plants for soil heating with the goal to improve the growth of plants. The prediction and analysis of the processes involved in these applications rests on a thorough quantitative understanding of combined heat and mass transfer processes in porous media because the energy transfer in the ground is intimately connected with energy transport by moving water - either in liquid or vapor form. This is an involved process not yet understood sufficiently to make accurate predictions possible. The present work will therefore sift and evaluate the recent literature on this subject which is scattered in many periodicals, to pinpoint areas where research is still needed, to derive the best models for analytic work based on present knowledge, and to apply them to problems encountered in the applications mentioned above. The present work will emphasize the simplification of existing models, which is highly complicated for porous media heat and mass transfer to arrive at experimentally verifiable computer solutions. The experimental data will be derived from an ongoing project associated with the use of the ground to store thermal energy. The specific research topics will include heat conduction in a porous matrix, transport of water vapor by diffusion and transport of liquid water by convection and capillary forces.
SUPPORTED BY U.S. National Science Foundation, Div. of Engineering

1.0204,
SOLAR ENERGY FOR SUPPLEMENTAL HEATING OF TURKEY HOUSES
K.A. Jordan, University of Minnesota, St. Paul Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *St. Paul, Minnesota* 55101 (7093-20401-013A)
OBJECTIVE: Develop design criteria for use of solar energy for heating fatilities used for rearing turkeys in Northern U. S. climates.
APPROACH: Basic design parameters developed for use of solar energy in heating poultry houses will be modified and used to design a solar heating system for a turkey rearing house in Northern U. S. The system design will be tested on a turkey production facility in Minnesota.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Alabama - North Mississippi Area

1.0205,
SOLAR ENERGY GRAIN DRYING (MINNESOTA)
R.V. Morey, University of Minnesota, St. Paul Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *St. Paul, Minnesota* 55101 (3090-15706-006-A)
OBJECTIVE: Determine the economic and technical feasibility of using solar energy to supplement or replace other fuels in drying grain.
APPROACH: Conduct research on the application of solar energy for drying corn. Test use of a solar collector as the only heat source for an instorage drying system and as a supplemental heat source for a batch grain dryer. Evaluate a prototype solar collector under indigenous weather and operating conditions.
PROGRESS: A solar energy drying system was tested in the fall 1974 harvest season at the University of Minnesota Southwest Experiment Station, Lamberton, Minnesota. Approximately 3600 bu of wet corn were dried from 24% to 15% moisture content, wet basis, from November 7 to December 5. A bin drying system was utilized with an airflow rate of approximately 2.5 cfm per wet bushel. Two solar collectors of approximately 1000 square feet of horizontal surface area each were used to preheat the air. The collectors were air supported and consisted of a top layer of clear vinyl plastic and two layers of black plastic to absorb solar energy. The drying air was heated an average of 5.5 F. The temperature rise attributed to the solar collectors was 2 F (approximately 14 million Btu collected over the test period). Conversion of electrical energy input to the drying fan into heat energy accounted for the remaining 3.5 F temperature rise. The collection efficiency, defined as the ratio of energy collected to the measured direct plus indirect solar radiation energy on one square foot of horizontal area, was 54% over the 28-day test period. Efficiencies calculated on a daily basis fluctuated greatly which was explained by energy storage in the soil under the solar collectors. Measured direct plus indirect solar radiation was approximately 60% of the estimated total clear day radiation available at 44.3 N latitude for the 28-day test.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Kansas - Nebraska Area

1.0206,
FIELD EVALUATION OF SOLAR ENERGY GRAIN DRYING IN MINNESOTA
R.V. Morey, University of Minnesota, St. Paul Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *St. Paul, Minnesota* 55101 (3090-15707-015-A)
OBJECTIVE: Determine the economic and technical feasibility of using solar energy to supplement or replace other fuels in drying grain.
APPROACH: Conduct at Minnesota Agricultural Experiment Station and selected field locations research on the application of solar energy for drying corn. Solar energy will be used with a batch-in-bin drying system early in the season, and later with low temperature in-storage drying. Solar drying will be compared to drying with various combinations of high temperature drying and natural air drying. The range of ambient air conditions, solar radiation available and collected, airflow rates and energy consumption will be recorded along with the rate of drying. Particular attention will be given to data that will be useful in drying simulation projects underway.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Kansas - Nebraska Area

1.0207,
COMBINATION HIGH-TEMPERATURE, LOW-TEMPERATURE DRYING TO IMPROVE ENERGY UTILIZATION AND GRAIN QUALITY
R.V. Morey, University of Minnesota, St. Paul Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *St. Paul, Minnesota* 55101 (MIN-12-023)
OBJECTIVE: Evaluate energy utilization and grain quality improvements for combination high-temperature, low temperature drying, compare results with computer models for predicting drying performance, develop information of immediate use for extension grain drying programs.
APPROACH: Field evaluation will be carried out on the grain drying-handling system at the Rosemount Experiment Station. High temperature drying (200-250 F) will be followed by five variations of low temperature, low airflow (0.5 to 1.0 cfm/bu) drying plus a control (no low-temperature drying). Temperature, airflow energy and grain quality data will be taken. Results will be used for further validation of computer models of the drying process and in extension grain drying programs.
PROGRESS: Study of energy requirements and grain quality changes during combination high-temperature, low-temperature drying continued on production scale system during fall 1976 drying season. Treatments involved various combinations of initial drying in automatic batch dryer at 200 and 300 F followed by low-temperature drying at 1/2, 1 and 1 1/2 cfm per bushel. Grain was discharged at 22 and 19% moisture content wet basis, hot from high-temperature dryer, cooled and completed in bin with natural air. Dryeration was evaluated as well as conventional (control) high-temperature drying to 15 1/2% w.b. Because of low incoming moisture contents some treatments were evaluated on strictly low-temperature basis. Propane and electrical energy requirements, and grain moisture contents were recorded. Grain samples were taken to evaluate susceptibility to breakage and mechanical damage. 1975 field results were used for validation of a computer simulation model of low-temperature drying with good agreement between measured and computed results. Model was used to evaluate low-temperature drying using ambient air or supplemental solar heat. Results showed dry matter decomposition and final moisture contents obtained with 2 to 2.5 F of supplemental solar heat can also be obtained without supplemental heat by increasing airflow rate by approximately 10% or decreasing initial moisture.
SUPPORTED BY Minnesota State Government

1.0208,
DRYING HIGH MOISTURE SEED AND GRAIN TO ENHANCE QUALITY AND MARKETABILITY
A.H. Boyd, Mississippi State University, Agricultural & Forestry Experiment Station, Dept. of Agronomy, *102 Experiment Station Bldg., Mississippi State, Mississippi* 39762 (MIS-6219)
OBJECTIVE: Develop techniques for drying forage crop, soybean and small grain seeds for maximum seed quality and marketability. Applications of solar energy to replace fossil fuels in drying applications. Evaluation of single and multiple screw stirring devices as they affect rate and uniformity of seed drying.
APPROACH: Determine heat tolerance, maximum rate and moisture/temperature relationships for soybeans, bahiagrass and selected cereal seeds. Emphasis on solar energy will be for adaptive research (technical and economic) and utilization of solar heat or maximum replacement of fossil fuel on a practical basis. Evaluation of mechanical stirring devices will be done primarily with co-operating farmers and manufacturers because large masses of material are needed for proper evaluation for drying rate and uniformity.
PROGRESS: The resistance to air flow characteristics of combine run bahiagrass seed were determined. Drying studies at 39, 43, and 46 degrees C indicated that adequate seed quality could be obtained at these temperature regimes. Moisture interchange between overdried and underdried soybeans approached to within 1% of average moisture content in two (2) to four (4) days depending on temperature. After 70 days of storage there remained slight (0.17-0.45%) differences in moisture content. Ouality evaluations indicated statistically no significant difference in germination of the two portions after 70 days' storage.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Mississippi

1.0209,
POULTRY HOUSE HEATING AND MANURE DRYING UTILIZING SOLAR ENERGY
W.H. Brown, Mississippi State University, Agricultural & Forestry Experiment Station, Dept. of Agricultural Engineering, *102 Experiment Station Bldg., Mississippi State, Mississippi* 39762 (7095-20400-006A(1))
OBJECTIVE: Develop simple, low-cost solar collectors by modification of existing poultry houses, evaluate the magnitude of space heating of a caged-layer house that can be obtained by solar energy, and develop and evaluate equipment for using solar energy for manure drying.
APPROACH: A conventional poultry house roof will be modified to become a solar energy collector. The system will be used to heat a caged-layer facility to determine the magnitude of heating to be obtained from the use of solar energy. A manure dryer will be designed to use solar energy for drying of poultry manure, and a prototype dryer built and tested using manure from a caged-layer facility.
PROGRESS: The south facing wall of a pre-engineered metal building was converted to a solar collector for heating air. A second layer of corrugated metal was criss-crossed with the outer skin of the building to form horizontal air flow channels in the wall. The wall was painted with a selective black paint and corrugated fiberglass was used for glazing. Ambient air is heated as it passes horizontally through the collector. Temperature rises of 60-70 F. above ambient have been measured during the winter months, with collection efficiencies as high as 70% being measured. Air flow was varied from approximately 1-3 CFM per square foot of collector area. Total collector area is 480 square feet. A 2 x 8 x 16 foot horizontal rock bed is used for storage. One batch of 1600 broilers were placed in the house on 28 February and will remain in the house for 8 weeks.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Alabama - North Mississippi Area

1.0210,

RESEARCH EQUIPMENT DESIGN AND DEVELOPMENT

F.L. Shuman, Mississippi State University, Agricultural & Forestry Experiment Station, Dept. of Agricultural & Biological Eng. *102 Experiment Station Bldg., Mississippi State, Mississippi* 39762 (MIS-7006)

OBJECTIVE: Provide engineering assistance in the design, modification and development of experimental research equipment. Determine the feasibility of 'in-house' fabrication of such equipment as opposed to contracting for fabrication or purchase of commercially available equipment. Provide assistance in developing specifications for research equipment to be purchased, leased or obtained by contract.

APPROACH: Establish and staff an engineering facility to provide continuing assistance to Mississippi Agricultural and Forestry Experiment Station scientists in the design, supervision of construction, modification, and development of experimental research equipment.

PROGRESS: Work associated with the Environmental Chamber-Biology Laboratory-Greenhouse Facility for Alcorn State University consisted of revision to satisfy budgetary limitations as well as supervision and inspection of various phases of construction. A portable working model filtration system was designed, constructed, and tested for use in the Enology Laboratory. The model will be used initially to process laboratory output. Data and experience obtained from the model will be utilized in the design and selection of components for the full-scale system. Assistance also has been provided in the design and construction of facilities and equipment for the folowing: beef cattle corral and cattle weighing, a cotton sacking attachment for picking research plots, a solids transport pumping system, pulpwood handling equipment, portable mechanical grape harvesting equipment, and a solar drier for poultry manure, and others.

SUPPORTED BY Mississippi State Government

1.0211,

POULTRY HOUSE HEATING AND MANURE DRYING UTILIZING SOLAR ENERGY IN A PRE-ENGINEERED METAL BUILDING

R.E. Forbes, Mississippi State University, School of Engineering, Dept. of Mech Engin. *Suite 101 Engineering Bldg., Mississippi State, Mississippi* 39762

A pre-engineered metal building was modified so as to use the sloped (70 degrees from the horizontal) south-facing wall as the major component of a once-through solar air heater. Horizontal flow channels were formed in the wall by criss-crossing a second layer of corrugated metal with the outer skin of the building. The channels were 1 foot wide, 1-1/2 inches deep and 24 feet long. Ambient air is pulled through the channels using an induced draft fan. The outer skin of the building was painted with a selective black paint and glazed with corrugated clear fiberglass. Air flow rate was approximately 2 CFM per square foot of collector area. Total collector area was 480 square feet. The house was used as a poultry broiler house during the winter of 1976-77. Supplemental heat was provided by LP gas.

SUPPORTED BY U.S. Dept. of Energy

1.0212,

STRUCTURES AND EQUIPMENT FOR POULTRY PRODUCTION AND WASTE MANAGEMENT

F.N. Reece, U.S. Dept. of Agriculture, Agricultural Research Service, South Central Poultry Research Lab., *P.O. Box 5367, State College, Mississippi* 39762 (7502-20400-001)

OBJECTIVE: Develop design criteria for structures and equipment that will improve production efficiency, reduce labor requirements, improve product quality, and facilitate waste handling for poultry production systems.

APPROACH: Factors that determine design criteria for structures and equipment for poultry production and waste management will be studied through the use of environmental research chambers, experimental buildings, equipment for mechanization of poultry production, and waste handling. Systems analysis through the use of computer modeling techniques will be applied to the determinate factors to evaluate and optimize important phases of poultry production and waste management.

PROGRESS: Significant progress has been made in reducing the energy required for poultry production by 1) refinement of the limited-area concept of poultry brooding by optimizing the floor-space requirements for chickens of various ages, development of a unique method of controlling floor space for various ages of chickens, and determining the minimum ventilation requirements for brooding chickens, and 2) development of methods for substituting solar energy for conventional energy for brooding broiler chickens. During the winter of 1976-77, these techniques were used to reduce the fuel required for growing broiler chickens to an average of 5 gallons of LP gas per 1000 chickens for two winter tests. Techniques were developed for measuring egg shell strength using standard testing instruments. These techniques include procedures for use of standard strength-of-materials instruments, and delineation of effects of egg storage conditions, especially relative humidity on shell strength.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Alabama - North Mississippi Area

1.0213,

SOLAR RESIDENTIAL DEMO PROJECTS - SINGLE FAMILY DWELLINGS

O.P. Wren, (No Performing Organization Reported), Tomaro Oaks, *Missouri*

No summary has been provided to the Smithsonian Science Information Exchange.

SUPPORTED BY U.S. Dept. of Housing & Urban Development

1.0214,

SOLAR HEATING & COOLING DEMONSTRATION - ST. LOUIS, MISSOURI

Unknown, Kelly Fischer Co., *St. Louis, Missouri*

The project combines a solar heating and domestic hot water preheating system with a contemporary split-level single family dwelling design. The wood house has 2,120 square feet of heated floor area under a double pitched roof. The south sloping roof has sufficient area for solar collectors to provide a major percentage of the dwelling's heating requirement. Large south-facing windows allow additional solar radiation to heat the house during the winter months but an extended roof overhang blocks summer sun penetration.

SOLAR APPLICATION: HEATING AND HOT WATER

COLLECTOR: 912 square foot liquid-cooled flat-plate manufactured by Revere Copper and Brass, Inc. The collectors are roof mounted and utilize a water-glycol solution for heat transfer and freeze protection.

STORAGE: 1,000 gallons of water within an insulated storage tank. Heat is transferred from the collectors to the tank by way of a water to water heat exchanger.

DISTRIBUTION: Forced air, natural radiation and convection. A heat transfer loop between the storage tank and a heat coil located in the primary supply duct provides heat for distribution by secondary supply ducts to the occupied spaces.

AUXILIARY ENERGY SYSTEM: Electric resistance furnace. Integrated with the solar distribution system, the furnace provides full or partial heating as required.

DOMESTIC HOT WATER SYSTEM: Domestic hot water is preheated by running a heat transfer loop from storage to a heat exchanger located in the conventional water heater.

COOLING: Natural ventilation.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0215,

APPLICATION OF SOLAR ENERGY TO THE DEHYDRATION OF ALFALFA

J. Bradley, Midwest Research Inst., *425 Volker Blvd., Kansas City, Missouri* 64110

No summary has been provided to the Smithsonian Science Information Exchange.

SUPPORTED BY U.S. Dept. of Energy

1.0216,

DEVELOPMENT OF EMPIRICAL EQUATIONS FOR SOLAR DRYING

D.B. Brooker, University of Missouri, Columbia Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *130 Jesse Hall, Columbia, Missouri* 65201 (3090-15705-013-A)

OBJECTIVE: Determine the economic and technical feasibility of using solar energy to supplement or replace other fuels in drying grain.

APPROACH: Conduct thin layer corn dryer tests in lab using input temp and airflows encountered in bin drying systems utilizing solar heat. Develop an empirical thin layer drying equation compatible with the grain drying simulation models developed by Bakker-Arkema, et al., at Michigan State University, and by others.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Kansas - Nebraska Area

1.0217,

SOLAR ENERGY WITH CHEMICAL HEAT STORAGE FOR GRAIN DRYING

D.B. Brooker, University of Missouri, Columbia Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *130 Jesse Hall, Columbia, Missouri* 65201 (3090-15706-023-A)

OBJECTIVE: Determine the effectiveness of eutectic salt solution as a heat storage medium for solar energy used in grain drying.

APPROACH: Determine the most effective temperature levels for storage and utilization of solar energy for different months during the fall drying season. Make up and test eutetic salt solutions with a melting point of about 55 F. Determine in the laboratory heat transfer between air and the heat storage under various conditions of airflow, storage container arrangement and temperatures.

PROGRESS: University of Missouri - Columbia - A literature review has been completeo and design criteria established for establishing a eutectic-salt energy storage. Inquiries are being made about the availability of chemicals and other equipment items.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Kansas - Nebraska Area

1.0218,

UTILIZATION OF THE CLIMATIC RESOURCE

W.L. Decker, University of Missouri, Columbia Campus, Agricultural Experiment Station, Dept. of Atmospheric Science, *130 Jesse Hall, Columbia, Missouri* 65201 (MO-00311)

OBJECTIVE: Examine the energy use of crop canopies in terms of photosynthetic and water efficiencies, develop workable mathematical expressions for predicting yield of important crops from weather data, describe the climate of the state in terms of probability of climatic events favorable for Missouri's agriculture.

APPROACH: The effect of canopy design on utilization of sunlight and evapotranspiration by soybeans will be studied along with the influence of atmospheric conditions. The prediction of yields for soybeans and other Missouri crops will be attempted from statistical models. Existing regression methods will be refined to increase their precision. An analysis of availability of solar energy and atmospheric radiation will be completed. Wind power as a resource will also be examined. Additional analyses to isolate management strategies most suitable to Missouri's climate will be made.

PROGRESS: The water demands of a soybean canopy were evaluated through use of paired lysimeters. The peak water use occurred in mid-July when the lysimeters used .26 and .29 inches per day. Dry weather reduced the soil water levels and inhibited the subsequent evapotranspiration. In mid-August the evapotranspiration in both lysimeters reached .1 inch per day, and the evapotranspiration in mid-September approached zero. From the lysimeter weights, the daily trends in evapotranspiration have also been calculated. The evaluation of the water potential and diffusive resistance of soybean leaves has continued. Using an incomplete block design the variability in both moisture characteristics for varying crop management systems are being examined.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Missouri

1.0219,

THE CLIMATIC RESOURCES OF THE NORTH CENTRAL REGION

W.L. Decker, University of Missouri, Columbia Campus, Agricultural Experiment Station, Dept. of Atmospheric Science, *130 Jesse Hall, Columbia, Missouri* 65201 (MO-00311-1)

OBJECTIVE: Define mathematical models for: predicting development, yield and quality; assessing the potential effects of weather modification in specific areas of the North Central Region. Delineate by graphs, maps, and tables the climatic variation in

wind, pan evaporation, evapotranspiration, soil temperature and cumulus clouds in the North Central Region and compute parameters that will describe the probabilities of occurrence of these data.
APPROACH: Mathematical models showing the effect of weather and climate on crop yields will be developed for soybeans, sorghums, etc. These models will be applied to projections of impact of climatic change and weather modification on agricultural production. Summarization of climatic elements important to agricultural operations will be developed with particular emphasis on evapotranspiration, soil temperatures, and wind.
PROGRESS: A review of crop-weather relationships have been made. This study includes an attempt to determine the impact of climate fluxuations on the yields of important crops in the north central region. These investigations have led to participation in national and international conferences in addition to the regional committee. Studies of the availability of alternate forms of energy (solar and wind) have been instigated. Data has been supplied for a regional study of geographic variability in solar energy. In addition, a thirty year record of solar energy in Missouri is being analyzed. The data are being compiled to produce a continuous record of solar radiation from which periods which threshold values can be identified.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Missouri

1.0220,

OPTIMIZATION OF SOLAR ENERGY FOR MODIFICATION OF SWINE FARROWING HOUSE ENVIRONMENTS

K.L. McFate, University of Missouri, Columbia Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *130 Jesse Hall, Columbia, Missouri* 65201 (7091-20400-002A(2))
OBJECTIVE: Determine availability and extent to which solar energy can be used to supplement heating and cooling of swine confinement systems, analyze the feasibility of recirculating ventilation air when conditioned by solar energy collecting systems, and evaluate methods of solar energy storage using available masses associated with livestock rearing.
APPROACH: Solar energy collectors and distribution systems will be designed for incorporation in a research facility currently under construction. Solar energy collected will be used to supplement electrical energy used in heating swine confinement facilities. Special emphasis will be on analysis of problems encountered when ventilation air from a swine facility is recurculated through solar collection units. Waste storage pits and tanks associated with swine units will be evaluated as potential energy storage sites.
PROGRESS: A solar energy collector and storage system has been installed at the new University Swine Research Complex. The system is based on hot water. Heat will be applied to the pig brooding area in the farrowing building by means of a floor pad heated by warm water. Two types of pads are to be investigated. One type is fabricated from copper tubing and metal sheets. Another is fabricated from plastic.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Alabama - North Mississippi Area

1.0221,

ENERGY UTILIZATION AS RELATED TO FARMSTEAD MECHANIZATION, MATERIALS HANDLING, AND RURAL LIVING

K.L. McFate, University of Missouri, Columbia Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *130 Jesse Hall, Columbia, Missouri* 65201 (MO-00077)
OBJECTIVE: Investigate feasibility, performance, costs, benefits related to optimum use of electricity (independently and/or in combination with other forms of energy, especially solar) as such relate to: Improved crop and livestock production facilities, handling and preservation of food products, and the effects of energy reductions and/or conservation in rural Missouri.
APPROACH: Determine optimum drying of grain (soybeans) with minimum energy input via field test. In cooperation with animal scientists, energy factors related to different building-production-facility systems will be determined. A combination solar energy-heat pump system will be installed and evaluated for use as major heat source in a farrowing house to determine design parameters and limitations.
PROGRESS: Focus of activity has been directed toward energy conservation, load management and energy substitution in all phases. Under MFEC project, electric energy consumption and electrical demands are being obtained within five major housing units of Swine Research Complex. Data collection, just beginning, will be used to assist in evalution of the Solar Energy Project. The solar energy collection system, coupled to a primary heat distribution system in one 20-sow wing of farrowing house, has been nearly completed. Heat collection should begin in January of 1977, with distribution of such heat made available to pig brooding (micro-environments) areas during the February-March farrowing period. Because of anticipated corrosion problems with aluminum radiators (proposed under pigs), copper units, as well as copper solar absorber plates, are being used. Data collection will begin during second quarter of 1977. In communicating the essentiality of energy for the FOOD CHAIN, and the interdependence of FOOD and ENERGY, a 4 to 6 page newsletter (FEC NEWS & NOTES) was prepared and mailed to some 700 power suppliers and educators, monthly. Energy conservation, management, and substitution were emphasized in FEC publications, conferences, and in slide-tape programs, distributed and used in some 36 states. An additional 50 sets were distributed in 1976.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Missouri

1.0222,

OPTIMIZATION OF SOLAR ENERGY FOR THE MODIFICATION OF SWINE PRODUCTION ENVIRONMENT

K.L. McFate, University of Missouri, Columbia Campus, School of Engineering, Dept. of Agricultural Engineering, *103 Engineering, Columbia, Missouri* 65201
No summary has been provided to the Smithsonian Science Information Exchange.
SUPPORTED BY U.S. Dept. of Energy

1.0223,

'PROOF-OF-CONCEPT' EXPERIMENT TO DESIGN AND EVALUATE A SOLAR ENERGY ACTIVATED SYSTEM FOR AGRICULTURAL AND INDUSTRIAL USES

J.L. Boone, University of Missouri, Rolla Campus, School of Engineering, Dept. of Electrical Engin, *Rolla, Missouri* 65401
No summary has been provided to the Smithsonian Science Information Exchange.
SUPPORTED BY University of Missouri

1.0224,

SOLAR HEATING & COOLING DEMONSTRATION - BLACKFEET INDIAN RESERVATION, MONTANA

Unknown, Blackfeet Tribe, *Blackfeet Indian Reservation, Montana*
As part of a larger program sponsored by HUD for self-help housing for the Blackfeet Tribe, five single family detached dwellings are combined with a solar heating and domestic hot water preheating system. The two-story homes total 1,226 square feet of heated floor area. Simply styled, the contemporary homes are sheathed by wood on a wood frame. The collectors are mounted on the steeply pitched south-facing roof.
SOLAR APPLICATION: HEATING AND HOT WATER
COLLECTOR: 192 square feet air-cooled flat-plate manufactured by Solar-Aire Inc. A blackened aluminum sheet with attached aluminum cups and baffles lies below two layers of fiberglass cover plates.
STORAGE: 746 cubic feet of rock within an insulated storage bin located in the basement. Partial separations in the storage bin prevent temperature stratification.
DISTRIBUTION: Forced air. The fan of an electric furnace circulates heated air from the collector to the storage bin. Storage radiates this heat directly to living spaces. Direct supply from collectors is sometimes fed into the return air of the furnace.
AUXILIARY ENERGY SYSTEM: Electric furnace. The furnace and a thermostatically controlled wood stove supplement the solar heating system.
DOMESTIC HOT WATER SYSTEM: A preheat coil embedded within the rock storage bin preheats the domestic hot water supply prior to passage through a conventional water heater.
COOLING: Natural ventilation.
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0225,

SOLAR HEATING AND COOLING DEMONSTRATION - OFFUTT AIR FORCE BASE, NEBRASKA

Unknown, U.S. Dept. of Defense, Air Force, *Offutt Air Force Base, Omaha, Nebraska* 68113
OPERATIONAL DATE: April 1977. Building Type: Residential, single family, 1996 sq. ft. (total); 1597 (conditioned). Application: Heating and Hot water. Collector Type: Liquid-flat-plate, (sq. ft.): 468. Storage Type: Water, 217 sq. ft.
OBJECTIVE: To compare systems: liquid, air, and higher performance collectors in a cold climate.
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0226,

SOLAR HEATING AND COOLING DEMONSTRATION - OFFUTT AIR FORCE BASE, NEBRASKA

Unknown, U.S. Dept. of Defense, Air Force, *Offutt Air Force Base, Omaha, Nebraska* 68113
OPERATIONAL DATE: April 1977. Building Type: Residential, single family, 1996 sq. ft. (total); 1597 (conditioned). Application: Heating and Hot water. Collector Type: Air flat-plate, (sq. ft.): 702. Storage Type: Rock, 400 sq. ft.
OBJECTIVE: To compare systems: liquid, air, and higher performance collectors in a cold climate.
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0227,

SOLAR HEATING AND COOLING DEMONSTRATION - OFFUTT AIR FORCE BASE, NEBRASKA

Unknown, U.S. Dept. of Defense, Air Force, *Offutt Air Force Base, Omaha, Nebraska* 68113
OPERATIONAL DATE: April 1977. Building Type: Residential, single family, 1996 sq. ft. (total); 1597 (conditioned). Application: Heating and Hot water. Collector Type: Evacuated tube, (sq. ft.): 608. Storage Type: Water, 217 sq. ft.
OBJECTIVE: To compare systems: liquid, air, and higher performance collectors in a cold climate.
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0228,

ENVIRONMENTAL DESIGN CRITERIA FOR LIVESTOCK HOUSING

J.A. Deshazer, University of Nebraska, Lincoln Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Lincoln, Nebraska* 68508 (NEB-11-027)
OBJECTIVE: Develop mathematical models for swine, beef, and poultry capable of predicting animal production as a function of environmental factors. Evaluate existing and future designs of livestock housing as applied to Nebraska by way of the mathematical model and through field test.
APPROACH: The production model will be based on an energy balance describing the metabolizable energy intake, energy dissipated heat loss, and the energy required per unit of production as related to the environment of the animal. Energy dissipation will be measured for poultry and baby pigs with a partitional calorimeter and extended when appropriate to other livestock. The calorimeter can continuously measure the total sensible, radiative, convective, and evaporative heat losses and O(2) consumption and CO(2) production of livestock. The production model will be tested with existing and future production and environmental data obtained from field studies. The performance of beef cattle in open front housing will be compared to open feedlot conditions under field conditions.
PROGRESS: An existing swine modified, open-front building, 43.9 3.6 m, for growing and finishing pigs from 14 kg to market weight was altered so one-quarter of the building included a solar heating system. The adjacent quarter was a conventional unit and was used as the control for the experiment. The solar unit reduced the electrical heating requirement by 25% so 3.5 kW-hr. per pig for the period from January 23, 1976 to April 16, 1976. However, the electrical heating savings was offset by the fan energy required to transport the solar heat. A storage system should be considered if an active heat

collection system is utilized. A simulation model was developed to determine the relationship between fuel conservation methods and swine performance. Decreasing the thermostat setting from 18C to 2C saved approximately 18 kW-hr./pig and increased feed consumption by 4 kg/pig-housed. Reducing the exposure factor of the swine building from 1.5 W/pig.C to 0.5 W/pig.C reduced the heating requirement of the building by approximately 13 kW hr./pig-housed but had no affect on swine performance. Through mathematical modeling of livestock systems,it was shown that of the baby meat animals, hogs are the most sensitive to environmental temperatures with a critical temperature of 32C, t (Text Truncated - Exceeds Capacity)

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Nebraska

1.0229,
USE OF SOLAR ENERGY IN A MODIFIED OPEN-FRONT SWINE FINISHING UNIT

J.A. Deshazer, University of Nebraska, Lincoln Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Lincoln, Nebraska* 68508 (7099-20400-010-A1)

OBJECTIVE: Determine the feasibility of using solar energy for substitution of fossil fuel in heating swine finishing shelters, to develop solar collectors which will perform the dual function of collecting solar energy for heating ventilation air and reclaiming heat from exhaust ventilation air.

APPROACH: A swine production house will be equipped with specially designed solar collectors which will heat ventilation air with solar energy and reclaim latent and sensible heat from exhaust ventilation air. Comparison will be made between the experimental unit and a conventional production unit.

PROGRESS: A 144' x 12' modified open front (MOF) swine finishing unit was altered so that one quarter was solar heated by a 36' x 6' flat plate collector. Another quarter of the building was kept as a conventional MOF finishing building for comparison with the solar MOF. The flat plate collector was made of 1/2' exterior plywood painted with Nextel 3M paint and double glazed with Tedlar at a material cost of approximately $3.00/ft 2. The inside air was mixed with outside air and heated by the flat plate collector when the collector temperature was greater than the attic temperature. The heated air was transported to the sleeping area of the building at an additional material cost of $3.00/ft of collector for ducting and fan. Electric heating was provided by 250 W infrared bulbs. Ninety-six pigs that weighed 30 lb. each were placed in the building on Jan. 23rd. By use of solar heating, 178 kW-hr. was saved from Jan. 23rd to Apr. 16, 1976. This equals 3.7 kW-hr./pig. The average feed efficiency was 2.90 lb. feed/lb. gain for the solar side and 2.78 lb. feed/lb. gain for the conventional side. The average daily gain was 1.55 lb. for the solar side and 1.61 lb. for the conventional side. The difference in performance of the pigs may be partially accounted for by the difference in air movement around the young pig and building temperature difference for the older pigs when heating was not required.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Alabama - North Mississippi Area

1.0230,
EQUIPMENT AND CONSTRUCTION MATERIALS TO MEET ENVIRONMENTAL DESIGN CRITERIA FOR LIVESTOCK FACILITIES

N.C. Teter, University of Nebraska, Lincoln Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Lincoln, Nebraska* 68508 (NEB-11-43)

OBJECTIVE: Test especially designed and constructed buildings and collect mass flow data for heat and moisture. Design buildings for better energy use in animal production. Use simulation models for optimizing beef, swine and dairy production facilities.

APPROACH: Multi-cooperative agreements for mutual benefit of industrial suppliers of buildings, building materials and equipment; farm producers; and University and USDA research personnel will be developed to study and evaluate innovative structural design and equipment. Buildings constructed will be evaluated for the economy of design related to benefits derived from environmental control. Simulation models are to be extended to relate use of solar energy, recovery of latent heat of vaporization, and similar innovations to the production economics.

PROGRESS: Facilities were built to evaluate solar heat collection for swine finishing. At a cost of $100 per cubic yeard, six inch wide reinforced, insulated concrete walls four feet high can be cast-in-place to make satisfactory swine house walls. Cost of solid walls was $62 per cubic yard. One to one and one-half percent floor slope gives good velocity for a gutter flushing 1900 liters per flush will adequately serve 4 gutters 0.76 m. wide and o.1 m. deep. PIP (plastic irrigation pipe) is sufficiently strong for use as drains for swine flushings. Black polyethylene plastic film (4 mil) melts when used as an unventilated black plate in a solar collector. Concrete block laid on the side can be easily aligned on screeded sand beds to make underfloor air channels for storage of solar heat.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Nebraska

1.0231,
SOLAR ENERGY FOR GRAIN DRYING IN NORTH CENTRAL REGION

T.L. Thompson, University of Nebraska, Lincoln Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Lincoln, Nebraska* 68508 (3090-15708-008-A)

OBJECTIVE: Determine, through mathematical modeling and computer simulation, the feasibility and relative effectiveness of using solar energy as supplemental heat for grain drying in the various states and locations within the North Central region.

APPROACH: Adapt existing computer models for simulation of low-temperature grain drying to include input of heat from solar energy. Obtain weather and solar data for selected points in the North Central States and convert into form compatable with the simulation model. Run simulated drying tests with various levels of heat added in proportion to historical record of weather conditions and availability of solar energy for the selected locations. Determine minimum airflow rates, and/or drying times that will permit drying of grain from various initial moisture levels without excessive deterioration.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Kansas - Nebraska Area

1.0232,
SOLAR ENERGY FOR DRYING CORN IN U.S. PRODUCING AREAS

T.L. Thompson, University of Nebraska, Lincoln Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Lincoln, Nebraska* 68508 (3090-15705-022-A)

OBJECTIVE: Determine through computer simulation, the relative effectiveness of solar energy for in-storage drying of corn in the principal U.S. corn producing areas.

APPROACH: Using available historical weather data, determine the effect of solar energy when used with in-storage drying systems on the total energy required and on overall drying costs. Various management strategies involving different levels of heat supplementation, fan operating schedules, harvest dates and moisture contents will be evaluated. Guidelines will be developed for managing low-temperature drying systems for 3 harvest dates and 3 moisture levels at selected locations. Probabilities of successful drying will be based on reducing corn moisture levels to 15 percent with 0.5 percent, or less, dry matter loss.

PROGRESS: University of Nebraska - Additional simulation runs were completed for central Iowa conditions studying various fan operation schedules, levels of solar and supplemental heat and spring drying periods. A similar series was begun for Indiana conditions. Tables showing the probability of various temperatures and equilibrium moisture contents were generated for one location in each state in the North Central Region for use in defining winter periods when natural air does not accomplish drying.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Kansas - Nebraska Area

1.0233,
CONSERVATION OF ENERGY AND NUTRIENTS IN LIVESTOCK RESIDUES IN HANDLING AND STORAGE

C.B. Golbertson, University of Nebraska, Lincoln Campus, U.S. Dept. of Agriculture Agricultural Research Service, Agricultural Engineering Research, *Keim Hall, Room 329, Lincoln, Nebraska* 68503 (3416-20400-002)

OBJECTIVE: Determine energy requirements for reducing and controlling water content of beef cattle and swine manure; nitrogen losses with water reduction and storage of manure, and the effect of manure depths on rate of water loss and nitrogen transformation; and study functioning of handling and storage in a prototype swine facility.

APPROACH: Predetermined depths of diluted manure are loaded into beakers on 48-hour intervals and dried to equilibrium moisture content in insulated vaults with selected energy inputs. Daily beaker weights record water loss. Weekly analyses determine nitrogen transformation. Continuous monitoring of temperatures (ambient, manure and plenum), relative humidity, and energy used, will provide data to determine feasibility of application of solar conventional energy sources.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Mid Great Plains Area

1.0234,
RESEARCH AND DEVELOPMENT OF THE SOLAR KING LOW-MEDIUM GRADE THERMAL CONVERSION PROCESS AND MACHINE

B. Pardo, Solar King Inc., *277 Gould St., Reno, Nevada* 89502

The objective of this program is to demonstrate the feasibility of the Solar king, Inc. engine concept by assembling and testing a 5HP and a 25HP hydraulic pump utilizing high pressure resulting from the thermal expansions of a working fluid. In addition, the theoretical capability of the concept will be evaluated to establish actual and potential performance parameters. This work is aimed at Agricultural applications.

Two tasks will be performed to demonstrate the feasibility of the Solar King, Inc. engine concept.

Taks 1: Dismantle 5 HP engine located at Reno Nevada. Reassemble at Baylor University in Test Loop. Perform Theoretical analysis and compare with test results.

Task 2: Procure parts for a 25 HP engine and test loop. Assemble. Perform analysis incorporating results of Task 1. Compare analysis to test results. Identify potential improvement in performance and recommend research plan to implement the recommendations.

The Contractor proposed a $5,000,000 overall program. His addendum to this proposal is for a $150,007 feasibility study on the 5 HP and 25 HP thermal engine. DSE is funding $41,000 (Task 1) of this $150,000 program by this action and may fund the remaining $109,007 as a second increment subject to successful completion of the first task and availability of funds. Any future procurement will be subject to the data generated from this feasibility study and its adaptability to the Solar Program.

The research and development activities will be performed at Baylor University, Waco, Texas; Dr. Wesley M. Alexander, Director of the Baylor Institute of Environmental Studies, will be the Principal Investigator. Brian D. Pardo, President, Solar King, Incorporated will be responsible for research and development activities.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0235,
INTEGRATED SINGLE FAMILY SOLAR HEATING HOT WATER SYSTEM USING AIR COLLECTORS INTEGRAL TO BUILDING STRUCTURES (ABBREV)

J. Christopher, Contemporary Systems Inc., *Jeffrey, New Hampshire* 03452 (NAS8-32243)

Development of an integrated single family solar heating and hot water system using air collectors integral to building structurers, air mover, rock storage, air/water, and heat exchanger.

Contemporary Systems, Inc., will design, develop and deliver two identical single family solar assisted heating and hot water systems to two sites. The heating and hot water systems use air heating flat-plate collectors, that are made from aluminum sheets and are double glazed. Rock storage and an air-to-water heat exchanger will be used. (DOE/CS-0010)

SUPPORTED BY U.S. Dept. of Energy, Office of Conservation & Solar Applications, Div. of Solar Applications

1.0236,

SOLAR HEATING & COOLING DEMONSTRATION - OLD BRIDGE, NEW JERSEY

Unknown, Jespa Enterprises, *Old Bridge, New Jersey* 08857

The contemporary single family dwelling fits 1,704 square feet of heated floor area into a compact two story plan. The dwelling's compactness as well as increased wall, floor, and ceiling insulation and a sun room greatly improve the building's thermal characteristics. Heating and domestic hot water preheating are provided by a warm-air solar system.

SOLAR APPLICATION: HEATING AND HOT WATER

COLLECTOR: 368.8 square feet air-cooled flat-plate manufactured by Sunworks. A separate 74.2 square feet of liquid-cooled flat-plate collectors are used for domestic hot water preheating.

STORAGE: 840 cubic feet of 2 inch to 4 inch rock within a storage bin located beneath the first floor. Domestic hot water storage is separate.

DISTRIBUTION: Forced air. Air is blown through heated rock storage directly to the living space through supply ducts.

AUXILIARY ENERGY SYSTEM: Oil-fired water heater. Water to air heat exchange coil located in primary supply duct provides full or partial energy boost.

DOMESTIC HOT WATER SYSTEM: A copper immersion coil in a closed loop from collectors preheats the domestic water supply in an 80 gallon tank. Water from preheat tank passes through a conventional water heater prior to distribution.

COOLING: Natural ventilation.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0237,

SOLAR HEATING & COOLING DEMONSTRATION - BLACKWOOD, NEW JERSEY

Unknown, Korman Corp., *Blackwood, New Jersey* 08012

The project combines a solar heating and domestic hot water preheating system with two single family detached dwellings. Each of two-story dwellings with basements has approximately 1,900 square feet of heated floor area. The solar collectors are mounted on the steep south-sloping roof.

SOLAR APPLICATION: HEATING AND HOT WATER

COLLECTOR: 528 and 576 square feet liquid-cooled flat-plate manufactured by G.E.

STORAGE: 850 gallons of water within an insulated cylindrical storage tank buried next to the foundation. Heat from the collectors is transferred to the tank by a water to water heat exchanger.

DISTRIBUTION: Forced air. Both house designs utilize a heat coil located in the primary supply duct which is heated by hot water from storage circulating through it. Air is heated as it is blown past the coil en route to the occupied spaces.

AUXILIARY ENERGY SYSTEM: Oil-fired furnace, electric resistance. One scheme has an oil-fired furnace supplying hot water to a fan coil in the supply duct; the other uses an electric resistance coil.

DOMESTIC HOT WATER SYSTEM: The domestic hot water supply is preheated by circulating the water through a heat exchanger in the storage tank prior to entering the conventional water heater.

COOLING: Natural ventilation.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0238,

HEATING GREENHOUSES WITH SOLAR ENERGY

D.R. Mears, Rutgers the State University of New Jersey, New Brunswick Campus, Agricultural Experiment Station, Dept. of Agricultural & Biological Eng, *Old Queens Bldg., New Brunswick, New Jersey* 08903 (7097-20690-008-A2)

OBJECTIVE: Develop and evaluate practical systems for heating greenhouses with warm water obtained from low cost solar collectors, and develop techniques for reducing heat losses from greenhouses.

APPROACH: Determine specific mechanisms of heat losses from greenhouses utilizing an instrumented outdoor greenhouse and an environmental chamber. Develop and test methods of reducing heat losses with multiple layers of plastic, reflective insulation, movable insulation shields of various materials, or other means. Develop low-cost solar heat collectors from layers of clear and black plastic films using water and air as fluids. Investigate methods of exchanging heat between warmed water and the greenhouse through warmed soil beds, circulating water in plastic envelopes on the floor, and warm water circulating between multiple layers of the roof and walls.

PROGRESS: A 36' x 48' gutter-connected house was prepared for studies of the heat exchange characteristics of a pipe loop in a composite rock/water floor. Solar collector tests are being conducted to determine minimum water flow requirements. Very encouraging results are being obtained in the research on the 17' x 24' test greenhouse which is being heated with an automatically controlled integrated solar system. Floor temperatures of 75 F will maintain a 60 F greenhouse temperature at 10 F outside. Early season high root zone temperatures have caused no discernable problems. Increased fruit size is being observed. Although analysis of an entire heating season's performance is needed for economic analysis, preliminary projections indicate a return on the investment from fuel savings minus operating costs on the order of 10% per year at current prices.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0239,

HEATING GREENHOUSES WITH SOLAR ENERGY

D.R. Mears, Rutgers the State University of New Jersey, New Brunswick Campus, Agricultural Experiment Station, Dept. of Biological & Agriculture Engineering, *Old Queens Bldg., New Brunswick, New Jersey* 08903 (7006-20690-019-A)

OBJECTIVE: Evaluate and refine research prototypes of solar heating greenhouse systems using solar heated water and investigate methods for reducing greenhouse energy use, and low-energy methods of cooling greenhouses.

APPROACH: Continue evaluation of a 13'x28' solar-heated water collector module used to heat a 17'x24' greenhouse. Design, test, and evaluate three 13'x96' solar-heated water collectors each utilizing different framing materials, wood, steel, and aluminum. Use these collector modules to heat water to be stored in three types of floor storage systems, 9'-deep gravel floor with no concrete cap, 9'-deep gravel with porous concrete cap, and 12'-deep gravel floor with walkways only having a porous concrete cap. Modify a 26'x30' greenhouse to test cooling by using movable plastic-film curtains and water films to extract surplus heat from a greenhouse attic and store it in the floor systems.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0240,

ENGINEERING GREENHOUSE SYSTEMS AND ENVIRONMENTS

W.J. Roberts, Rutgers the State University of New Jersey, New Brunswick Campus, Agricultural Experiment Station, Dept. of Agricultural & Biological Eng, *Old Queens Bldg., New Brunswick, New Jersey* 08903 (NJ00556)

OBJECTIVE: Improve the engineering and horticultural aspects of greenhouse vegetable production systems adaptable to year-round production under New Jersey condition and determine the impact of an expanded industry of this type.

APPROACH: Models and full size prototypes of selected structural systems will be designed, built, tested and evaluated. Various automatic controls for maintenance of growing crops will be studied from an engineering and horticultural standpoint. Steaming systems will be designed and tested. Soluble salt, amonium and nitrate toxicity problems will be evaluated by soil test procedures. The possibilities of utilizing waste heat from industrial operations for greenhouse vegetable production will be studied. The role of a year-round vegetable greenhouse industry in the community will be examined. The concern to costs and returns, land and other resource utilization (including labor needs) and impact of such an industry on the environment.

PROGRESS: A functioning solar-assisted hearing system has been built and is being tested. Components include a 17' x 24' slant-leg, double-covered, air-inflated polyethylene greenhouse, a 13' by 28' Rutgers polyethylene solar collector, a 15.7' by 12.2' by 9' porous, concrete-capped gravel floor for heat exchange and storage, an insulating black polyethylene curtain, two 20' by 5' polyethylene vertical curtain heat exchangers, a 200', 1' diameter polyethylene pipe heat exchange loop installed in the gravel for supplemental fossil fuel heating, a hot water boiler and automatic controls. A fall crop of greenhouse tomatoes is being grown to determine if the warm floor is affecting the plants. The system is working very well and the solar contribution to the energy requirement is substantial. A 36' by 48' greenhouse is being modified to conform to commercially available gutter-connected structures 3 bays wide. A vinyl liner was installed in the floor using a technique developed for retrofitting existing greenhouses that have interior posts. A composite floor is being installed in stages so the parts can be studied individually. A heat-saving curtain system has been installed to heat several different materials. Tests are being conducted with small solar collectors in an effort to improve the efficiency of the absorber surface and achieve complete absorber surface wetting with minimum pump horsepower.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, New Jersey

1.0241,

NUTRITION, DISEASE AND MANAGEMENT OF LIGHTWEIGHT FEEDER CATTLE

A.B. Nelson, New Mexico State University, Las Cruces Campus, Agricultural Experiment Station, Dept. of Animal Range & Wildlife Sci, *University Park, Las Cruces, New Mexico* 88070 (NM04108-1)

OBJECTIVE: Plan and construct a facility for studying nutrition, disease, and management of lightweight feeder and stocker cattle; compare certain nutrition, disease, and management procedures in backgrounding programs.

APPROACH: Acquire land and plan and construct facility. Compare wheat pasture vs. drylot, type of supplemental feed for lightweight cattle, and kind and time of inoculation if facilities are available during the third year (25 head per lot and replicated).

PROGRESS: Construction is complete on a feedlot (48 feeding pens, sorting pens, holding pens, sick pens and scale) and a 70' x 70' building for working cattle (crowding chute, squeeze chute, scale and dipping vat). The center pivot sprinkler system will be operational upon completion of the irrigation well. Funds have been allocated for solar-heated residence, an office-laboratory building and a 40' x 120' storage shed-shop building. Two short-term feeding trials have been completed. Average daily gain and feed efficiency of yearling steers were not affected by level of protein (8.5 or 11.0%) in the ration but implanation (Synovex) increased gain 20% and improved feed efficiency 17%. Weaner calves gained 48% faster and 29% more efficiently for 26 days when fed a high energy (75% concentrate) ration. Calves processed immediately upon arrival to the feedlot gained 22% faster and 20% more efficiently than those processed one week after arrival.

SUPPORTED BY New Mexico State Government

1.0242,

UTILIZATION OF SOLAR ENERGY AND THE DEVELOPMENT OF AN EGYPTIAN VILLAGE - AN INTEGRATED FIELD PROJECT

E. Lumsdaine, New Mexico State University, Las Cruces Campus, School of Engineering, Dept. of Mech Engin, *University Park, Las Cruces, New Mexico* 88003

In a collaborative research project between Drs. Salah Arafa and and Cynthia Nelson of the American University in Cairo and Dr. Edward Lumsdaine of the new Mexico University, a study will be made of the social impact upon an Egyptian village of the introduction of solar technology. The village which has neither electricity nor an acceptable water supply, is already favorably disposed to the change. Both 'low' technologies, such as water heaters and ovens, and 'high' technology, such as electricity generation, will be selected and applied to food preparation, water purification, water pumping, and biomass conversion. The effectiveness of the new technologies in fulfilling the villagers' needs as well as fitting into their social structure will be evaluated. Attempts will be made to generalize the experience for application to similar rural communities.

The problem of the impact of technology on life style is prevalent at all socio-economic levels in almost all countries of the world. Low technology, isolated rural villages are particularly prone to social disruption as technology is introduced into the village life. This is true in Egypt, other LDC's, as well as in parts of Southwestern U.S.

This award supports the costs of the project at the New Mexico State University, while a companion award, INT78-01127, supports the costs at the American University in Cairo.
SUPPORTED BY U.S. National Science Foundation, Div. of International Programs

1.0243,

THE NEW MEXICO STATE UNIVERSITY SOLAR HEATED AND COOLED DEMONSTRATION HOME

R.L. SanMartin, New Mexico State University, Las Cruces Campus, School of Engineering, Dept. of Mech Engin, *University Park, Las Cruces, New Mexico* 88003

The objective of this study is to design, build, and extensively test a single-family residence which will utilize solar energy to provide the required heating, cooling, and hot water for the home. The design utilizes currently available construction materials to show that a functional solar home can be built today. It also demonstrates how the solar system can be architecturally integrated into the residence. This is a research facility in that it will test solar collectors, heating and cooling equipment, and other solar utilization devices. It is a demonstration unit in that it demonstrated to home builders and occupants that solar energy is reliable, inexpensive, clean, and comfortable.
SUPPORTED BY New Mexico State Government

1.0244,

SOLAR IRRIGATION PUMPING DEMONSTRATION PROJECT

R.L. SanMartin, New Mexico State University, Las Cruces Campus, School of Engineering, Dept. of Mech Engin, *University Park, Las Cruces, New Mexico* 88003

No summary has been provided to the Smithsonian Science Information Exchange.
SUPPORTED BY New Mexico State Government

1.0245,

SOLAR POWERED IRRIGATION SYSTEMS

R. Alvis, Sandia Lab., *P.O. Box 5800, Albuquerque, New Mexico* 87115 (E(29-1)-0789)

The objective of this project is to evaluate the feasibility of utilizing solar energy to power agricultural irrigation systems, and to demonstrate a first generation system using state-of-the-art equipment. The project will be approached in two phases. First, a system analysis phase will include the generation of site specific optimization techniques as well as a national demand model. Second, a demonstration phase will involve the development of a shallow well solar thermal irrigation system and its installation on a working farm in the Estancia Valley of New Mexico. The system, approximately 25 kWe, will use commercially available components. Specifications for the demonstration will be complete in May 1976, assembly will take place during the first three months of 1977 and the system will be operational in June 1977. Workshops, seminars and technical publications in agriculture periodicals will be used to communicate the data obtained during the program. (ERDA 77-31)
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0246,

PERFORMANCE ANALYSIS OF A DOUBLE-POLYETHYLENE INFLATED HYBRID SOLAR SPACE HEATING SYSTEM

S.R. Kenin, Solar Room Co., *Taos, New Mexico* 87571 (EG-77-G-04-4129)

The purpose of this project is to determine the amount of solar heat that can be supplied by a double-glazed solar greenhouse collector for heating a single family dwelling. Other results will also indicate the actual cost effectiveness of such a solar collector. A test module consisting of 4 test cells has been constructed. Three of the cells have various configurations of solar greenhouse collectors and storage methods. The 4th cell is a control cell and has no provisions for solar collection or storage. Data is being gathered on the amount of electric back-up heat and amount of solar heat being supplied to each cell. The project is currently in the test phase, i.e., acquiring data during the heating season, and will move into the data analysis phase during the late spring. This project is subcontracted.
SUPPORTED BY U.S. Dept. of Energy

1.0247,

APPLICATION OF SOLAR ENERGY TO MOBILE HOME HEATING AND COOLING

J.D. Balcomb, U.S. Dept. of Energy, Los Alamos Scientific Lab., *P.O. Box 1663, Los Alamos, New Mexico* 87544

The objective of this program is to continue the development-demonstration program for solar heating and cooling of mobile/modular style homes. The program involves the design and fabrication of four prototype units. Each unit will emphasize a different aspect of the program. The LASL modular home demonstration program will provide an initial demonstration of the feasibility of factory integrating solar heating and cooling systems into mobile and modular homes. Design procedures will evolve to meet the heating and cooling requirements for the range of climates which exist in the U.S. The results and final design will be made available to mobile and modular home manufacturers as part of the technology transfer commitment.
SUPPORTED BY U.S. Dept. of Energy, Div. of Biomedical & Environmental Research

1.0248,

TRANSPORT OF TOXIC SOLAR ENERGY WORKING FLUIDS RELEASED TO THE ATMOSPHERE - INFORMATION REQUIREMENTS

S. Barr, U.S. Dept. of Energy, Los Alamos Scientific Lab., *P.O. Box 1663, Los Alamos, New Mexico* 87544

A review of installations, materials, properties and toxicities, and possible release events will be conducted. The results will identify the hazards to humans and to the environment resulting from releases of solar working fluids and will indicate information needs.
SUPPORTED BY U.S. Dept. of Energy, Div. of Biomedical & Environmental Research

1.0249,

POTENTIAL EFFECTS OF SOLAR SYSTEM WORKING FLUIDS AS ECOSYSTEM CONTAMINANTS

D. Wilson, U.S. Dept. of Energy, Los Alamos Scientific Lab., *P.O. Box 1663, Los Alamos, New Mexico* 87544

The project will emphasize development of a screening capability to evaluate systematically the behavior and effects of working fluids in four areas: (1) on plant growth and reproduction; (2) on soil microflora as evidenced by altered rates of plant litter reduction; (3) on mobilization and transport of chemicals from soil water; and (4) for tracing the transport of materials and residues in pathways relevant to human consumption.
SUPPORTED BY U.S. Dept. of Energy, Div. of Biomedical & Environmental Research

1.0250,

SOLAR HEATING AND COOLING DEMONSTRATION - SANTA FE, NEW MEXICO

Unknown, Wayne Nichols Communico, *Santa Fe, New Mexico*

The project is a two-story single family dwelling integrated with solar heating, cooling, and domestic hot water preheating system. Thick adobe walls behind a south-facing greenhouse of the L-shaped plan absorbs heat and transmits it to the living spaces. Excess heat from the top of the greenhouse is drawn off by two ducts and sent into rock storage bins located below the living and dining room floor. An airlock entry and extra insulation improve the thermal characteristics of the 1,900 square foot dwelling. North walls are wood stud construction with a stucco exterior finish.
SOLAR APPLICATION: HEATING, COOLING AND HOT WATER COLLECTOR: South-facing greenhouse. A separate 34 square foot liquid-cooled flat-plate collector manufactured by Sunsource provides domestic hot water preheating.
STORAGE: 872 cubic feet of 3 inch to 4 inch diameter rock within two insulated storage bins beneath the first floor. Domestic hot water storage of 40 gallons is separate.
DISTRIBUTION: Forced air. Two ducts draw off excess greenhouse heat to the two rock storage bins. A fan distributes this heat by ducts to the living space. The floor above the storage bins and the adobe wall of the greenhouse act as radiant heat sources.
AUXILIARY ENERGY SYSTEM: Electric coil resistance. A three-stage 10 Kw electric resistance coil is the primary supply. Duct heats air from storage bin as required.
DOMESTIC HOT WATER SYSTEM: A separate liquid-cooled flat-plate collector preheats the domestic hot water supply by circulating the heated water through a heat exchanger in the conventional water heat storage tank.
COOLING: The system is designed to draw cool air into rock storage at night and then distribute cool air to the house during the day.
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0251,

DEVELOPMENT OF A SINGLE FAMILY ABSORPTION CHILLER FOR USE IN A SOLAR HEATING AND COOLING SYSTEM

W.J. Bierman, Carrier Corp., Energy Systems Division, *Carrier Tower, P.O. Box 4800, Syracuse, New York* 13221 (EG-77-C-03-1587)

This project will design, construct and operate a direct air cooled absorption machine in the 3 to 5 ton size. This machine will be capable of delivering 45 degree F water to a coil with an ambient 95 degree F (d.b.) and a fluid supply temperature no greater than 230 degrees F. The thermal coefficient of performance is targeted for 0.65 to 0.70. The unit will be capable of delivering a high percentage of its rated capacity at ambient temperatures up to 110 degrees F. Carrier will evaluate various refrigerant-organic absorbent combinations to be used in the design of the absorption machine. Carrier will perform cycle analysis, design optimization, and will construct and test a prototype. (DOE/CS-0010)
SUPPORTED BY U.S. Dept. of Energy, Office of Conservation & Solar Applications, Div. of Solar Applications

1.0252,

BIOLOGICAL AND SYNTHETIC SYSTEMS FOR PRODUCTION OF HYDROGEN FROM WATER

A.I. Krasna, Columbia University, College of Physicians & Surgeons, Dept. of Biochemistry, *630 W. 168th St., New York, New York* 10032

This award is a two-year continuation of NSF grant AER 7408381 whose aim is the production of hydrogen and oxygen gas by the biophotolysis of water with solar energy in a system composed of chloroplasts and the enzyme hydrogenase or a suitable catalyst. The research will address the key problems in the development of a continuous system for the simultaneous production of hydrogen and oxygen which are the inhibitory effects of oxygen on hydrogen production and the long-term instability of biological systems. Oxygen inhibits the enzyme hydrogenase and oxidizes the associated low-potential electron carriers. Removal of oxygen from an absorbent in a compartment separated from the site where hydrogen is produced would permit a continuous cyclic operation, and systems for the absorption of oxygen based on hemoglobin and myoglobin, synthetic heme analogues, transition metal chelate compounds, and perfluorohydrocarbons will be examined. The instability of enzyme systems will be circumvented by the use of a partially synthetic one in which the hydrogenase enzyme is replaced by heterogeneous or homogeneous chemical catalysts like platinum, palladium, or heavy metal hydrogenation catalysts. In addition, the development of a completely synthetic method in which the chloroplasts are also replaced by chemical catalysts will be pursued using a synthetic photoreducing system with proflavin as the catalyst.
SUPPORTED BY U.S. National Science Foundation, Div. of Advanced Energy & Resources Research & Technology

1.0253,

HEATING OF GREENHOUSES AND RURAL RESIDENCES WITH SOLAR ENERGY

L.D. Albright, Cornell University, Ithaca Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Ithaca, New York* 14850 (7005-20690-018-A)

OBJECTIVE: Develop and evaluate an active-passive hybrid solar heating system utilizing low-cost solar

heat collection and retrieval and the concept of variable mass for solar heating of greenhouses.
APPROACH: Test and demonstrate a new low-cost concept for utilizing solar energy to heat greenhouses; match solar heating components into the 'Q-Sol' system to produce compatible night and day greehnouse conditions, with the 'night' greenhouse effectively shrunk to contain only the plants and a heat source by using a variable thermal mass and a hybrid active/static means of solar energy retrieval. Determine night temperature requirements of a variety of plants to find those suited to the characteristics of passive solar heating systems. Formulate a method to inter-relate capital costs, market factors, and plant factors as an analysis tool to predict cost effectiveness of patented greehouse solar heating systems.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0254,
ENERGY CLIMATE OF NEW YORK STATE
B.E. Dethier, Cornell University, Ithaca Campus, Agricultural Experiment Station, Dept. of Agronomy, *Ithaca, New York* 14850 (NYC-125434)
OBJECTIVE: Describe and quantify the energy climate of New York State. Establish a data base for future interdisciplinary studies at the Center.
APPROACH: Solar radiation and wind direction and velocity at 10 meters will be observed and recorded at several sites (Harford, Ithaca, Mt. Pleasant, Aurora, Canton, Chazy and Valatie). These data will be used with data from other stations (Geneva, New York City, etc.) to obtain probability of occurrence of events meaningful to agriculture and other energy related activities. This information will be useful in characterizing energy consumption and in assessing the potential for extracting energy from wind for utilizing solar energy. Final results will be presented in map and tabular form for presentation in suitable station publications. The data will also be included in the monthly weather summaries currently published by the unit.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, New York

1.0255,
EFFICIENT ENERGY AND WATER USE IN PLANT PRODUCTION
L.H. Lemon, Cornell University, Ithaca Campus, Agricultural Experiment Station, *Ithaca, New York* 14850 (1090-12331-002-A)
OBJECTIVE: By measuring and modeling determine limiting environmental and genetic factors related to production of cultivated plants.
APPROACH: Manipulate environmental and genetic factors through management and breeding to improve production thus increase the energy (solar and fossil fuel) and water use efficiency.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, North Atlantic Area

1.0256,
SOLAR HEATING OF GREENHOUSES AND RESIDENCES
D.R. Price, Cornell University, Ithaca Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Ithaca, New York* 14850 (7094-20690-005-A2)
OBJECTIVE: Analyze, design, and evaluate the combinations of collection of devices and storage systems to utilize solar energy as effectively as possible to provide the greatest portion of the energy requirements for heating and cooling greenhouses and rural residences.
APPROACH: Assemble information on present applicable technologies of solar heating and cooling, develop an atlas of solar radiation data for the Northeast, identify energy load patterns for greenhouses and residences in the Northeast, and develop mathematical models to evaluate and optimize applications of known technologies to the heating and cooling requirements. Utilize an existing orthorhombic solar energy house to test and evaluate collector and storage systems.
PROGRESS: An air handling and backup heating system was added for the 40-ton crushed rock heat storage bed in the newly constructed double plastic 22' x 48' greenhouse. The rock is stored in 40-ft benches in the greenhouse. The system was put into operation December 10 for winter testing. The insulation of the north wall and north roof using rigid urethane insulation with reflective foil covering is in process and comparisons will be made with the other insulation techniques. Work is underway to complete the expanding tube technique for insulating over the ceiling. Various types and weights of cloth are being considered for this application. The first increment of permanent reflective foam insulation has been installed on the north wall of an experimental greenhouse, and heating data have been acquired. An experiment has been designed to carefully monitor light levels at various points in the greenhouse as more and more glass area is covered.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0257,
SOLAR HEATING AND COOLING OF GREENHOUSES AND RURAL RESIDENCES
D.R. Price, Cornell University, Ithaca Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Ithaca, New York* 14850 (NYC-123326)
OBJECTIVE: This study is proposed to provide sound technical information to evaluate the overall merits of utilizing solar energy for heating and cooling of greenhouses and residences. The effort will be directed toward the application of present collector and storage technologies to greenhouses and residence systems. The general objective will be to analyze, design, and test the combination of solar collection devices and storage systems to utilize solar energy as effectively as possible to provide the greatest possible portion of the energy required.
APPROACH: An interdisciplinary team of engineers, architects and economists will carry out detailed engineering analyses, design of building forms, and economic analyses to satisfy the objectives of the project. An existing solar energy house will be instrumented to measure the effectiveness of solar energy use. Mathematical models of the greenhouse heat balance will be developed and used to simulate the application of solar energy to heating of greenhouses.
PROGRESS: A mathematical model was developed to predict the steady-periodic thermal behavior of a greenhouse. Good agreement (or - 2 C) was achieved between actual and predicted greenhouse environments. Techniques were investigated to reduce heat loss from a greenhouse. Black cloth pulled over the lower chord and around the walls resulted in 50% reduction in night time heat loss in a glass greenhouse used for the testing. A covering of 6 mil polyethylene over the glass greenhouse also resulted in about a 50% reduction. A rock storage system was designed for use in a solar heated greenhouse. The rock storage system was designed for modular construction so that existing houses may be retrofitted. The modules were tested in the laboratory and found to be effective units for heat storage. The rock storage units are used as the growing benches in the greenhouse.
SUPPORTED BY New York State Government

1.0258,
STUDIES OF PHOTOSYNTHETIC ENERGY CONVERSION
R.K. Clayton, Cornell University, Ithaca Campus, School of Biological Sciences, Dept. of Genetic Development & Physiol, *Ithaca, New York* 14850 (E(11-1)-3162)
Description: Primary processes in bacterial photosynthesis are best studied with purified reaction center preparations. Optical absorbance changes and electron paramagnetic resonance signals in reaction centers now reveal two short-lived excited states of bacteriochlorophyll as possible intermediates in the photochemical process. At least one of these states has properties of the triplet state. Further optical studies are planned to explore the natures and roles of these states. We will attempt to construct a solar battery made from dried films of photosynthetic reaction centers or membrane fragments plus electron donors and acceptors. We will continue to study the roles of iron, ubiquinone and water in the photochemical function of reaction centers. Both chemical (as electron acceptor) and physical (structural; dielectric) roles are being investigated.
Bibliographic references: (1) C.A. Wraight, J.S. Leigh, P.L. Dutton and R.K. Clayton, Biochem. Biophys. Acta 333, 401 (1974); (2) W.W. Parson, R.K. Clayton and R.C. Cogdell, 'Excited states of photosynthetic reaction centers at low redox potentials', in preparation (1974).
Addenda: Estimated calendar year funding reported as 1974 $100,000, 1975 $100,000. This project is also supported by National Science Foundation; Cornell University.
SUPPORTED BY U.S. Dept. of Energy, Unspecified Unit

1.0259,
SOLAR HEATING AND COOLING DEMONSTRATION - BUFFALO, NEW YORK
Unknown, Innovative Building Systems Inc., *Buffalo, New York*
The project is a large two story contemporary single family dwelling that incorporates a solar heating and domestic hot water preheating system. The wood frame house contains 3,350 square feet of heated floor area on three levels including a full basement. The energy load of the house is reduced by added insulation, double layer glass, and large south-facing windows. The south slope of the double pitched roof is fitted to the optimum angle for solar collection, thereby creating an interesting north-facing clerestory that allows sunlight to enter the second floor family room.
SOLAR APPLICATION: HEATING, COOLING AND HOT WATER COLLECTOR: 669 square feet liquid-cooled flat-plate manufactured by PPG. A water-antifreeze solution is used as the heat transfer medium to alleviate potential freezing problems.
STORAGE: 2,000 gallons of water within an insulated reinforced concreted septic tank. A water to water heat exchanger transfers captured heat from the collectors to the storage media.
DISTRIBUTION: Forced air. Air is forced over a water to air heat exchanger for distribution to the dwelling spaces by ducts.
AUXILIARY ENERGY SYSTEM: Two electric heat pumps. One utilizes outside air for operation while the other uses indoor return air. Both are integrated with the solar system.
DOMESTIC HOT WATER SYSTEM: A heat exchanger in storage preheats the water in the 80 gallon tank of the conventional heater. This tank boosts temperature as required.
COOLING: Electric heat pump. An air to air heat pump provides cooling for the dwelling in the summer months.
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0260,
SOLAR HEATING & COOLING DEMONSTRATION - LAGRANGEVILLE, NEW YORK
Unknown, Solar Structures Inc., *Lagrangeville, New York* 12540
The project is a two-story, single family detached dwelling with 3,200 sqare feet of heated floor area utilizing solar energy for heating and domestic hot water preheating. The design incorporates a number of energy conserving features including: south-facing windows with horizontal louvers projected over them to exclude the summer sunlight and to admit the winter sunlight with its beneficial heat gain; a closed water loop to conserve energy normally lost from fireplace, kitchen appliances, laundry, and bathroom fixtures; and added wall, roof and ceiling insulation.
SOLAR APPLICATION: HEATING AND HOT WATER COLLECTOR: 1,200 square feet liquid-cooled flat-plate manufactured by Revere. The double-glazed panels cover a selectively coated copper absorbing surface.
STORAGE: 3,000 gallons of water within an insulated storage tank located in the basement. A water to water heat exchanger transfers heat from the solar collector to the water tank.
DISTRIBUTION: Forced air. Hot water from storage circulates through a heating coil in the primary supply duct. A fan blows air over the coils. The heated air is distributed by ducts to the occupied spaces.
AUXILIARY ENERGY SYSTEM: Electrical resistance heaters, heat pumps. Two 15 KW resistance heaters are located in the pump supply duct in addition to a 2 1/2 ton heat pump with a fan coil unit.
DOMESTIC HOT WATER SYSTEM: The domestic hot water supply is preheated within a 25 gallon tank by circulating 'hot' water from the main heat storage tank through copper coils. The preheated water passes through a conventional water heater prior to distribution.

COOLING: Natural ventilation. Heat pump is not solar assisted.
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0261,

SOLAR HEATING & COOLING DEMONSTRATION - FORT BRAGG, NORTH CAROLINA

Unknown, U.S. Dept. of Defense, Army, *Fort Bragg, North Carolina* 28307

OPERATIONAL DATE: April 1977. BUILDING TYPE: Residential, single family, 1,392 sq. ft. APPLICATION: Heating and Hot water. COLLECTOR TYPE: Liquid flat-plate, (sq. ft.): 504. STORAGE TYPE: WATER, 159.96 cu.ft./unit.

OBJECTIVE: To demonstrate the use of east-west facing dwellings with solar heating.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0262,

SOLAR HEATING & COOLING DEMONSTRATION - FORT BRAGG, NORTH CAROLINA

Unknown, U.S. Dept. of Defense, Army, *Fort Bragg, North Carolina* 28307

OPERATIONAL DATE: April 1977. BUILDING TYPE: Residential, single family, 1,392 sq. ft. APPLICATION: Heating and Hot water. COLLECTOR TYPE: Liquid flat-plate, (sq. ft.): 384. STORAGE TYPE: WATER, 160 cu.ft./unit.

OBJECTIVE: To demonstrate the use of east-west facing dwellings with solar heating.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0263,

ENGINEERING FOR FLORICULTURAL AND ORNAMENTAL CROP PRODUCTION

K.R. Keller, University of North Carolina, North Carolina Agricultural & Technical State University, Agricultural Experiment Station, *N. Dudley St., Greensboro, North Carolina* 27411

The objectives are to reduce energy costs and to improve environmental control in greenhouses by incorporating rock bed storage systems to utilize solar energy.

SUPPORTED BY North Carolina State Government

1.0264,

ANIMAL IMPROVEMENT THROUGH BREEDING AND MANAGEMENT

K.R. Keller, University of North Carolina, North Carolina Agricultural & Technical State University, Agricultural Experiment Station, *N. Dudley St., Greensboro, North Carolina* 27411

The general research objectives are (1) to improve the reproductive efficiency of animals, (2) to improve the feed efficiency of animals, and (3) to develop housing and handling facilities that maximize production while being energy efficient.

The results of this research will improve the ratio of calories of utilizable energy per calorie of energy input than currently exists because the animals will become better energy converters. Reductions in the use of fossil fuels will be attained by using other sources such as solar energy for heating.

SUPPORTED BY North Carolina State Government

1.0265,

IMMEDIATE SOLAR-ENERGY UTILIZATION USING GREENHOUSE-BULK CURING AND DRYING SYSTEMS

K.R. Keller, University of North Carolina, North Carolina Agricultural & Technical State University, Agricultural Experiment Station, *N. Dudley St., Greensboro, North Carolina* 27411

The purpose is to provide practical aspects of immediate and effective utilization of solar energy for agriculture.

SUPPORTED BY North Carolina State Government

1.0266,

SOLAR ENERGY APPLICATION AND ENERGY CONSERVATION FOR LOW INCOME RURAL FAMILIES

W.A. Streat, University of North Carolina, North Carolina Agricultural & Technical State University, School of Engineering, Dept. of Architectural Engineering, *N. Dudley St., Greensboro, North Carolina* 27411 (NC.X-PR-0001)

OBJECTIVE: Develop energy conserving designs of economically feasible systems to meet energy needs of housing for low income rural families.

APPROACH: Preliminary work will include making a survey of housing and energy needs of rural low income people of North Carolina and making a feasibility study of utilizing non-conventional energy sources in existing rural houses using solar energy. Price and performance data will be gathered on currently available solar hardware and computer codes will be written to perform systematic economic optimization studies. Cost effect system designs (one hydronic and one air) will be developed and made available to rural families.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, North Carolina

1.0267,

SOLAR ENERGY UTILIZATION IN TOBACCO BULK CURING/GREENHOUSE SYSTEM

B.K. Huang, University of North Carolina, North Carolina State University, Agricultural Experiment Station, Dept. of Biological & Agric Engineering, *Raleigh, North Carolina* 27600 (7095-20190-007-A(1))

OBJECTIVE: Provide for practical aspects of immediate and effective utilization of solar energy for tobacco curing and greenhouse crop production.

APPROACH: Based on previous research for this system, computer aided analyses, modeling and simulation will be used to evaluate and optimize the collector design, energy storage and automation of air flow during curing. These design changes will be made on the existing bulk curing/greenhouse structure. Tests will be conducted on tobacco curing and data necessary for performance and cost utilization and for further analysis and simulation will be collected using a microprocessor based data acquisition system. Tobacco seedling and other plant growth research will be conducted in a bulk curing/greenhouse structure. Continuous growth data will be taken to determine the optimum environment for multi-layer growth of tobacco seedlings. Other greenhouse crops will be grown and studied for maximum economical utilization of the structure as a greenhouse.

PROGRESS: The greenhouse/solar energy curing barn was used for 5 separate complete cures in 1976. Compared with the conventional curing barn, the solar curing system used 30 percent less fuel. The saving for the individual cures ranged from a low of 7 percent to a high of 40 percent. The low figure was obtained when two days of rain and three cool nights occurred during the peak energy requirement of leaf and stem drying. A thermal circuit model has been developed to help analyze the solar energy collection and utilization of this system. The initial results are in good agreement with the measured results. The greenhouse models developed by Takukura and Chandra have been adapted to the greenhouse/bulk curing barn system. They are being modified to obtain system responses for various modes of operation.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0268,

SYSTEMS APPROACH TO TOBACCO MECHANIZATION

B.K. Huang, University of North Carolina, North Carolina State University, Agricultural Experiment Station, Dept. of Biological & Agric Engineering, *Raleigh, North Carolina* 27600 (NC02504)

OBJECTIVE: Characterize biological factors related to producing and processing tobacco; reduce labor and production costs; improve tobacco quality; develop technology for greater modification and control of tobacco properties; optimize use of solar energy in greenhouse bulk curing system; improve efficiency of tobacco marketing system.

APPROACH: Laboratory, field, greenhouse and computer modeling studies to: Determine optimal conditions for uniform seed germination and seedling growth; identify economic mechanized system for production of high quality transplants and for transplanting; further mechanize and reduce energy requirements for harvesting and curing; relate process variables of curing to leaf and smoke chemistry for improved quality; study solar energy utilization in a greenhouse bulk curing system; evaluate and compare alternative market systems; further evaluate and test the concept of close-grown tobacco; develop computer models to optimize production systems.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, North Carolina

1.0269,

GREENHOUSE VEGETABLE PRODUCTION

C.H. Miller, University of North Carolina, North Carolina State University, Agricultural Experiment Station, Dept. of Horticultural Science, *Raleigh, North Carolina* 27600 (NC03558)

OBJECTIVE: Develop procedures for efficient production & protection of greenhouse vegetables. Rates, ratios & timing of nutrients will be studied with tomatoes & cucumbers including spatial arrangement, watering and media. Feasibility studies with new cvs. & other crops will be conducted. Insecticides & acaricides; mist evaporative systems, covering materials & structural modifications will be evaluated. With tomato & cucumber as test crops, arthropod pest species will be identified & life histories studied. Severity of pathogens on tomato & other crops will be studied. Control measures involving chemicals, cultural practices will be devised. Heating, cooling, humidity control & mechanization will be researched along with solar energy.

APPROACH: Standard and potential greenhouse crops will be provided specific environments necessary for each discipline with some overall perimeters providing bridges among disciplines (i.e., standard varieties, fertilizer treatments, pesticide treatments, and equipment for environmental modifications). Overall plant responses including yield and reaction to the biological and environmental hazards will be measured, evaluated and published.

PROGRESS: Greenhouse facilities are not completed, therefore, no significant research to report at this time.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, North Carolina

1.0270,

ALTERNATIVE ANIMAL WASTE PRETREATMENT - LAND DISPOSAL SYSTEMS

M.R. Overcash, University of North Carolina, North Carolina State University, Agricultural Experiment Station, Dept. of Agricultural & Biological Eng, *Raleigh, North Carolina* 27600 (NC09015)

OBJECTIVE: Functional and economic comparisons of three alternative waste disposal systems--direct land disposal, lagoon-land disposal and digestor-land disposal--under the constraints of land availability and water quality standards.

APPROACH: Degrees of pretreatment are studied in relation to disposal on plant-soil systems. The mechanism(s), capacity, and rate of organic carbon, nitrogen, heavy metals and bacterial removal are determined. Undisturbed soil cores with profile sampling delineate the pathways for removal of waste components. Soil-plant dynamics, performance of pretreatment schemes and economic factors are integrated in field studies.

PROGRESS: Lagoon pretreatment of swine waste has been demonstrated for heavy metals (Cu, Zn, Mn) and other cations (Ca, Mg, K, Na) with the effluent to be applied to a plant-soil system representing removals expressed as a percent of influent of 96, 92, 87, 80, 36, 24, 24, respectively. Sludge accumulations were documented to account for the removal and represented a very concentrated sludge requiring removal only after 15-20 years thus adding to the waste management advantages of this unit process. Results from land application of swine lagoon effluent (SLE) were that Coastal Bermuda uptakes of nitrogen and copper at the application rates of 400, 800 and 1600 kg N/ha/yr were 280 and 0.10, 460 and 0.14, 460 and 0.13 kg/ha/yr, respectively. Rainfall runoff of nitrogen from plots receiving SLE were the same at 300 and 600 kg N/ha/yr as that from control plots representing pasture management (180 and 300 kg fertilizer N/ha/yr). The rate of 1200 kg N/ha/yr of SLE gave higher nitrogen runoff. Soil accumulation of SLE applied cations continued in the second year with some detection of elevated concentration in the less permeable B-horizon. However, the bulk of the exchangeable cations are probably leaving in lateral soil-water interflow. Auxiliary equipment was developed for the

solar heated anaerobic digestor to allow interception of incoming light only when temperatures are below the mesophilic range and to provide insulation preventing heat loss during the remainder of time.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, North Carolina

1.0271,
SYSTEM APPROACH TO TOBACCO MECHANIZATION

R.S. Sowell, University of North Carolina, North Carolina State University, Agricultural Experiment Station, Dept. of Agricultural & Biological Eng, *Raleigh, North Carolina* 27600 (NC02501)
OBJECTIVE: Reduce labor and production costs by further mechanization and optimization of production inputs; improve tobacco quality by adjusting inputs in accordance with field measurements and by reducing crop variability.
APPROACH: An interplay between engineering of system components and model development. Develop computer models in concert with research and development of the various subsystems. Combine the subsystem models into a production system model that is designed to evaluate and compare production alternatives.
PROGRESS: Seedling storage research indicated that plants can be kept at 50(0)F for at least 1 week without loss of livability. Plant growth parameters, total light and light under the canopy were collected in plots of field grown tobacco throughout the growing season. Combination of ethrel treatment to reduce yellowing time with midrib crushing to accelerate stem drying makes it possible to bulk cure tobacco in 3 days. Time studies data were collected on a farm with a mechanized harvesting and curing system. The work in mechanical harvesting and bulk curing of stalk-cut air-cured tobacco was extended to include cigar filler. On farm tests of a device to uniformly load leaves into large mechanically-filled curing racks are encouraging. A greenhouse/solar curing barn was constructed and field tests indicated that it could provide satisfactory curing with 2/3 the fuel required by conventional bulk barns. Five products (cotton and four synthetics) were evaluated as possible substitutes for the burlap sheet currently used to market tobacco. Two items (plant growing and handling trays and automatic transplanter) designed and tested in this and its predecessor projects were licensed by manufacturers. A third item, large mechanically-filled curing racks, was commercialized.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, North Carolina

1.0272,
ENGINEERING FOR FLORICULTURAL AND ORNAMENTAL CROP PRODUCTION

D.H. Willits, University of North Carolina, North Carolina State University, Agricultural Experiment Station, Dept. of Biological & Agric Engineering, *Raleigh, North Carolina* 27600 (NC03549)
OBJECTIVE: Reduce energy costs and improve environmental control in greenhouses; reduce labor/production costs of nursery and greenhouse operations.
APPROACH: Attempts to reduce energy costs will be made by incorporating rock bed storage systems into greenhouses. Reduction of nighttime heat losses and development of alternate energy sources will be investigated. Mathematical models will be developed to facilitate improved environmental control. Attempts to reduce labor/production costs in nursery and greenhouse operations will be made by using a systems approach. Totally integrated production models will be developed and used to evaluate production alternatives and optimize resource allocations.
PROGRESS: This project was initiated July '76 to replace NC03420). The emphasis of this project will be on the reduction of energy costs for heating and cooling greenhouses. Previous work begun on mechanization of nursery and floricultural operations will also be continued in this project. Accomplishments under this project since July have been limited to the analysis of the data collected during the previous winter on the feasibility of storing energy collected within greenhouse during the day. The analyses revealed that approximately 8% of the total heat loss of the structure (7.6m x 8.5m quonset greenhouse) was stored in the rock beds during a one week period in January which experienced 82.0 degree days (based on 15.6 C). Approximately 16% was stored during a milder week during the same month (73.5 degree days). Further analysis revealed that up to 26% of the total heat loss could have been stored during this latter period if the storage capacity had been large enough (approximately 15.4 tonnes of gravel were used in this study).
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, North Carolina

1.0273,
EFFECT OF AIR FLOW AND TEMPERATURE IN MECHANICAL DRYERS ON WHEAT QUALITY

C.W. Moilanen, North Dakota State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Fargo, North Dakota* 58103 (ND01421)
OBJECTIVE: Determine the effects of forced air velocities and temperatures during drying on the milling and macaroni processing qualities of durum wheat, and milling and baking qualities of hard red spring wheat.
APPROACH: An experimental dryer will be used on durum and hard red spring wheats. Experiment designed around Box-Wilson technique. Five variables considered: Air Temperature, Air Velocity, Grain Moisture, Sample Position, and Column Thickness. Dried samples of durum will be evaluated for milling and macaroni processing qualities. Spring wheat samples will be evaluated for milling and baking qualities.
PROGRESS: A 100 foot long plastic covered solar collector of triangular cross section was instrumented and operated at the NDSU Experiment Station in Fargo. The collector was operated from late February to late June 1976. The amount of solar energy collected ranged from 2,898 BTU per hour to a high of 25,810 BTU per hour. The collector was operated only during the daylight hours during late February through April 30. When compared to propane gas at peak performance, the heat collected equaled about .3 gallons of gas per hour. It was concluded that this type of solar collector was not practical nor economical for this type of environmental conditions.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, North Dakota

1.0274,
VENTILATION FOR CONFINED CATTLE

R.L. Witz, North Dakota State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Fargo, North Dakota* 58103 (ND01428)
OBJECTIVE: Establish design criteria for ventilation systems for beef cattle confinement barns. Develop a heat exchanger to utilize the heat in the exhaust air from ventilation systems. Evaluate two types of commercially available ventilating systems.
APPROACH: This study will be made by installing a heat exchanger at the beef confinement barn and evaluating its operation. Additional laboratory studies will be made of the heat exchange between rocks and air for design criteria.
PROGRESS: Several days below -20 F this winter has given opportunity to further evaluation of frost accumulation in the heat-exchanger rock beds. We have been able to control frost and ice in the rock beds by using salt - about 1 lb. per day for each bed. Ethylene Glycol antifreeze was also tried. This appears to work well but a sprayer is needed for application and is much more costly. The antifreeze, however, does not have a corrosive effect. A recent design using this system indicated the heat retrieved each day would be equivalent to $96.20 of 2 1-2 cent per kw hr electricity in a hog barn designed for 1,000 pigs and on a -30 F day.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, North Dakota

1.0275,
SOLAR HEATING & COOLING DEMONSTRATION - DUBLIN, OHIO

Unknown, Building Industry Associates of Central Ohio, *Dublin, Ohio* 43017
The project is a single family detached dwelling that employs a solar heating and domestic hot water preheating system. Insulated boards on sliding tracks sealed to jambs with magnetic gaskets control heat losses from the dwelling's large window area. Exterior walls have been insulated with a new sandwich-type sheathing boards with foamed insulation between metallic foil sheets. The circular fireplace is designed for heat recovery. All electric lights have dimmers to reduce energy consumption. Living spaces total 3,648 square feet.
SOLAR APPLICATION: HEATING AND HOT WATER
COLLECTOR: 1,166 square feet air-cooled flat-plate manufactured by Solaron. The black sheet metal absorber has two glass cover plates above and an airduct below.
STORAGE: 720 cubic feet of Rocks, 1 1/2' in diameter, within a 10' x 10' x 7' insulated storage bin.
DISTRIBUTION: Forced air. Air is blown through the rock bin by an air-handling module containing blower, motor and drives. The heated air is distributed through the ducts to living spaces.
AUXILIARY ENERGY SYSTEM: Electrical heat. pump. The heat pump draws air over coils in the primary supply duct to supplement the solar heating system.
DOMESTIC HOT WATER SYSTEM: A heat exchange coil in the air-handling module preheats water as air flows from collector to rock storage. The heated water is then returned to a 60 gallon storage tank.
COOLING: Natural ventilation.
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0276,
US-SOVIET COOPERATIVE RESEARCH IN PHOTOSYNTHESIS

B. Ke, Charles F. Kettering Foundation, *150 E. South College St., Yellow Springs, Ohio* 45387
This proposal involves joint research work over a 6-month period by Dr. Bacon Ke of Kettering Research Laboratory and Dr. Shuvalov of the U.S.S.R. Academy of Sciences Institute of Photosynthesis. (Dr. Shuvalov is a leading Soviet specialist in the area of photosynthesis, a basic process of conversion by green plants of solar energy into chemical energy.) The joint work to be done at Kettering would be in the area of the photosynthesis process and would focus on the identification and characteristics of an intermediate which serves as the acceptor of electrons in the photosystem. The proposed work would contribute to the search for such an intermediate.
SUPPORTED BY U.S. National Science Foundation, Div. of International Programs

1.0277,
UTILIZATION OF WASTE FROM VEGETABLES PROCESSING PLANTS

J.R. Geisman, Ohio Agricultural Research & Development Center, *Wooster, Ohio* 44691 (OHO00636)
OBJECTIVE: Evaluate compaction and drying methods for reducing sludge volume produced in spent brine recycling; methods for reducing water volume for freshing salt stock cucumbers, dehydration techniques for recovering by-products from tomato processing; and develop ways for using solid waste from cabbage processing.
APPROACH: Studies will be done in commercial processing plants and the laboratory. Wastes will be collected and subjected to compaction, separation, and extraction of the various components by dehydration, reverse osmosis, partial pressure, combustion and chemical treatments as applicable. Emphasis will be placed upon the development of usable products and energy sources and the efficiency of the procedures required to recover such products from the plant wastes. Solar energy sources for recovery will be tested.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Ohio

1.0278,
SOLAR ENERGY GRAIN DRYING (OHIO)

H.M. Keener, Ohio Agricultural Research & Development Center, *Wooster, Ohio* 44691 (3090-15701-001-A)
OBJECTIVE: Determine the economic and technical feasibility of using solar energy to supplement or replace other fuels in drying grain.
APPROACH: Conduct research on the application of solar energy for drying soybeans and shelled corn. Test effectiveness of solar collectors for heating air used for grain drying and effect of weather variations on performance of solar collectors. Develop operational procedures for employing plastic-type solar collectors for bin drying of grain. Compare efficiency and cost of recommended unheated air-drying procedures.
PROGRESS: One drying test on soybeans and three on shelled corn were conducted from 10/4/74 - 1/24/75 using two solar heated and one unheated batch grain dryers. Grain moisture samples were taken at 6-inch intervals in grain beds 2-3 ft deep twice a day during the test. Air temperatures into and

from the solar collectors and into, within and from the grain were measured every 12 minutes. In addition, solar radiation and barometric pressure were collected at a nearby (within 1/4 mile) official weather station. Analysis of grain sample moistures indicated that the moisture removal due to the solar collectors (approximately 12 ft wide x 85 ft long) was as high as 232 lbs/day during November corn test, and 42 lbs/day during December corn test. Tests indicated that when grain was at high moisture (above 13% for soybeans and 20% for corn), operation of the drying fans at night on bins with or without solar collectors was advantageous from the drying standpoint. A computer program to analyze temperature data and calculate solar collector efficiencies, energy utilization and drying efficiencies has been developed. Analysis of October data gave solar collector efficiencies varying from 26-51%. Between the two solar collectors, (north-south and east-west orientation), no significant difference in efficiencies was noted.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Kansas - Nebraska Area

1.0279,

SOLAR HEAT FOR GRAIN DRYING IN OHIO

H.M. Keener, Ohio Agricultural Research & Development Center, *Wooster, Ohio* 44691 (3090-20598-020-A1)

OBJECTIVE: Determine the economic and technical feasibility of using solar energy to supplement or replace other fuels in drying grain.

APPROACH: Solar heat collectors (one with an insulating layer of styrofoam between the collector and soil) will be connected to two of three batch-in-bin dryers, and a comparison will be made between the drying rates of soybeans and shelled corn using solar heated air and unheated air. The studies will include the effects of various air flow rates imposed and the amounts of supplemental solar heat as a function of weather on the rate of drying and rate of grain deterioration. Air and grain temperatures will be recorded and used in analyzing the system. Grain probe samples will be analyzed for moisture content and grain quality. Dewpoint temperatures of air entering and existing the grain will be recorded. The data obtained will supplement and expand solar grain drying data base for Ohio weather begun during 1974 and 1975 and will also be used as validation data in computer simulation studies of solar grain drying.

PROGRESS: Data for drying of shelled corn and soybeans from the 1975 crop year were completed and analyzed. Two commercial air-supported plastic solar collectors were used to capture radiation, one insulated from the soil and the other uninsulated. The daily capture of energy with the insulated collector is only slightly more than with the uninsulated collector during June and is actually less during October and November. Results of the drying tests indicated that drying rates were nearly the same with the insulated and uninsulated systems. Problems from failures of seams of the plastic collectors, procured in 1974, were experienced in 1976. The benefits from supplemental solar heating, as compared with natural air, were demonstrated to be highly dependent upon harvest moisture content of the grain and prevailing weather conditions. Grain moisture contents above 18% and drying operations after mid-October benefitted from the supplemental heat. An intelligent management routine for fan operation is desirable when using a solar collector. During early stages of drying all-night fan operation can remove significant moisture, but later, when the drying front has moved significantly upward through the grain, it may be essential to shut off the fans at night. Shelled corn from the 1976 crop was dried using the same solar collec (Text Truncated - Exceeds Capacity)

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Kansas - Nebraska Area

1.0280,

SOLAR HEAT FOR GRAIN DRYING

H.M. Keener, Ohio Agricultural Research & Development Center, *Wooster, Ohio* 44691 (OHO00232-SS)

OBJECTIVE: Determine effectiveness of solar collectors in heating air, effects of solar heated air (low temperature) compared to unheated air on the rate of drying soybeans and shelled corn, effect of weather variations on solar collectors, operational procedures for using bin dryers with solar collectors.

APPROACH: Conduct a field study on integrated solar heat collector - grain drying systems under field conditions. Study will use three bins, each 14 ft. dia. x 8 ft. high. Two bins have solar collector units (an inflated plastic cover over a 1000 ft black plastic obsorber) connected for the heated air studies, one using continuous air flow and one moving drying air only during daylight; while one bin will be using unheated air in continuous operation. Simulation of solar drying systems will be made.

PROGRESS: 1976 field studies continued on air supported plastic film solar collectors. Corn drying conducted during October and November using solar heated air required fan energy of about .10 kwh/bu-pt of moisture removal during October and .16 kwh/bu-pt in November. Drying rate of solar heated system was about 1.5 bu/hr/100 ft of bin floor area when using 6 ft of collector area per 1 ft of bin floor area (based on drying grain from 25% to 20% moisture, w.b.). Dyanmic computer simulation models, OSAHS, has been developed for evaluating solar air heating collection systems. Model used to study effects of air flow rates and tilt angle on collector performance using 1972-76 Ohio weather data as input. Log model and 3 finite difference models of deep bed grain drying analyzed for their accuracy and speed of computation when inlet air conditions time varying. Model outputs compared with experimental 1974-75 solar drying studies. Results with log model of drying indicated it coulld predict within 4% actual moisture contents of deep bed when 1) time averaged temperatures and humidities are used as grain dryer inlet conditions, and 2) time constant for drying corrected for air velocity in deep bed. All finite difference models predicated moisture contents within 3% throughout bed. Computational speed (60% faster) and stability greatly improved on OARDC deep bed drying model compared with published versions of finite difference models. First and second order integration routines have been developed which are fast.

SUPPORTED BY Ohio State Government

1.0281,

ENGINEERING ANALYSES OF ENERGY STORAGE FOR AGRICULTURAL USES

H.M. Keener, Ohio Agricultural Research & Development Center, *Wooster, Ohio* 44691 (OHO00613)

OBJECTIVE: Evaluate known or synthesize systems for collection and storage of solar, waste, electrical or bioprocess heat for their applicability to conserve fossil fuels in agricultural systems.

APPROACH: Determine the functional characteristics of heat-dependent agricultural processes which may be amenable to substitution for fossil fuel heat. Determine the operating characteristics of candidate heat collection and storage devices. Determine, by systems analysis, the optimum match between collection/acquisition rate and heat storage capacity for each of the heat dependent processes, based upon criteria of fuel availability, space, or cost, etc. Specify and publish example systems which are feasible solutions to meeting heat requirements of agricultural process systems.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Ohio

1.0282,

CORN PRODUCTION METHODS TO ACHIEVE ENERGY CONSERVATION IN DRYING OHIO'S CORN CROP

H.M. Keener, Ohio Agricultural Research & Development Center, *Wooster, Ohio* 44691 (OHO00273-SS)

OBJECTIVE: Achieve significant reduction in the fossil fuel energy required to dry corn in Ohio by the combined use of alternative energy sources and energy-effective management techniques. Compile research results on crop management associated with corn grain water content at harvest and energy efficiencies of various methods of drying the grain. Disseminate results to Ohio's farm families and agribusiness in any manner necessary to achieve significant adoption of improvements.

APPROACH: Research work on energy requirements of corn production systems has been conducted over the last four years at OARDC. This work has involved analyzing energy uses in crop production. Also, studies on 1) solar and natural air drying systems, and 2) effects of time of planting, variety selection, weed control, fertilizer levels and other cultural alternatives on crop moisture, have been accomplished. Now, the available information will be compiled into a bulletin describing all aspects of energy conservation in harvesting and drying corn. Data may be collected from field trials or demonstration plots to supplement existing data.

SUPPORTED BY Ohio State Government

1.0283,

ALTERNATIVE ENERGY HEATING OF DAIRY PROCESS WATER

W.L. Roller, Ohio Agricultural Research & Development Center, *Wooster, Ohio* 44691 (OHO00274-SS)

OBJECTIVE: Determine, demonstrate and disseminate factual information on the management of alternative energies (such as animal heat in the milk, solar heat collected and offpeak electric energy) to decrease the demand for fossil fuel energy in the heating of Process Water on Ohio's Dairy farms.

APPROACH: An operating dairy production facility is available as part of the new OARDC Dairy Research Center. Alternative energy conservation system interactions have been modeled on the computer using design parameters as used by the Dairy Research Center architect for heating and storage capacities and process requirements. The simulation-optimum system of animal heat recovery, solar heat collection and off-peak electric heat make-up will be demonstrated by retrofitting to the facilities now nearing completion. All solar collectors used will be commercially available units as is the animal heat recovery and off-peak electric heating will be made. Factual information on energy savings will be disseminated via on-site field days and through the written, oral and visual media.

SUPPORTED BY Ohio State Government

1.0284,

IMPROVING SOYBEAN SEED QUALITY

A.F. Schmitthenner, Ohio Agricultural Research & Development Center, *Wooster, Ohio* 44691 (OHO00217-SS)

OBJECTIVE: Determine effects of environment and culture on seed quality. Study biology and control of phomopsis seed rot. Determine effects of insects on seed quality and rot. Develop harvesting methods to avoid quality loss. Improve tests for determining seed maturity and vigor.

APPROACH: Plots will be harvested at different dates for effects on seed germination vigor and infection. Time of and conditions necessary for Phomopsis infection and chemical and genetic control will be studied. Inducing early maturity by cutting and drying or by chemical dessicants will be attempted. Insect feeding on seed quality will be determined in the field and in cages. Cross-flow, counter-flow and closed cycle-heat pump drying systems, and optimum threshing and seed handling methods for ensuring seed quality will be developed.

PROGRESS: Phomopsis was isolated more frequently (75%) from soybean seed than Diaporthe phaseolorum var. sojae (15%) or D. phaseolorum var. caulivora (10%). Phomopsis seed infection was reduced by 1) planting soybeans after corn 2) using full-season varieties, 3) planting early varieties late, 4) harvesting as soon as seed were mature, and 5) plowing down soybean straw in the fall to reduce pycnidia development. Potassium (K) level in soil was negatively correlated with K deficiency symptoms and moldy seed and positively correlated with foliar K, yield and seed quality. Late varieties (Group III) had higher foliar K, fewer deficiency symptoms and fewer moldy seed than early (Group I) or mid-season (Group II) varieties. Benomyl applied to 12 varieties at three locations at 1/2 to 2 lb a.i./ac improved seed quality slightly among mid-season but not early and late varieties. Two species of thrips, two of plant bugs and the one spot stink bug placed on caged soybeans did not significantly reduce yield or seed weight at insect populations tested. Germination and Phomopsis tests of seed from caged soybeans are in progress. Studies in the Agr. Eng. Dept. are in progress on soybean harvesting, handling, and drying, including percentage germination loss and stress cracking in thin-layer drying tests for various varieties; comparison of solar and natural air drying; reverse air flow methods in deep bed drying; and use of dessicant 'paraquat' to speed up field dry-down prior to harvest.

SUPPORTED BY Ohio State Government

1.0285,

SOLAR HEAT FOR HEATING AND COOLING GREENHOUSES AND RESIDENCES

T.H. Short, Ohio Agricultural Research & Development Center, *Wooster, Ohio* 44691 (7098-20690-009-A2)

OBJECTIVE: Reduce current fossil fuel heating requirements for greenhouses and rural residences while maintaining or improving the environment within the structures.

APPROACH: Investigate use of properly controlled salt concentration to make solar ponds capable of storing solar energy at temperatures up to 80 or 90 C. Collect solar energy in two 18 by 90 ft greenhouses and store for later use in greenhouses or rural residences. Develop and evaluate methods of exchanging heat between solar ponds and greenhouses or residences. Develop and test mechanized methods of adding or removing insulating greenhouse covers.

PROGRESS: A greenhouse structure was placed over the top of the pond (16 mil Tedlar coated polyvinylchloride) and a reflector was put on the north wall in early November. This decreased heat loss and minimized debris problems. However, the cover decreases the light entering the pond. The total effect is still under investigation. The maximum charge temperature has been 110 F, less that the planned 180 F. The pond tends to stay near this temperature through the winter even with ice on the surface. The reasons for moderate temperature achievement is presently under investigation. Underwater radiation tests during the late summer indicated that deep pond light transmission was substantially less than expected. Exact collection efficiency still remains elusive. The pond is slowly cooling through the winter at a rate and temperature level similar to 1975-76. It is supposed that the heat loss to the soil beneath the pond may be higher than predicted. It was assumed in the original pond design that the soil beneath the pond would dry out and become insulative after a season of heating.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0286,

EXPERIMENTAL STUDIES ON A SOLAR POND FOR HEATING AND COOLING GREENHOUSES AND RESIDENCES

T.H. Short, Ohio Agricultural Research & Development Center, *Wooster, Ohio* 44691 (7008-20690-021-A)

OBJECTIVE: Demonstrate a working solar pond and heat extraction system for heating an adjacent greenhouse and evaluate the economic feasibility and efficiency of a solar pond as an integrated solar collector and heat storage unit for greenhouses and homes.

APPROACH: A salt pond (28x60x12 ft deep) will be monitored for daily temperature and salt concentration gradient. Radiation profiles above and within the pond will be studied under different weather conditions and seasons. The efficiency of a heat extraction system will be measured and the salt pond will be evaluated as a solar energy collection and storage system for providing solar heat for greenhouses or residences. Emphasis will be given to developing design criteria for optimum pond depth, required insulation in sides and bottom, required size of gradient zone, and required maximum salt concentration for stability and maintenance. A computer model will be developed to simulate the solar pond heating system and an energy accounting system will be developed to evaluate the various energy pathways in the experimental system.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0287,

RESEARCH ON SOLAR PONDS FOR HEATING AND COOLING GREENHOUSES AND RURAL RESIDENCES

T.H. Short, Ohio Agricultural Research & Development Center, *Wooster, Ohio* 44691 (OHO00238-SS)

OBJECTIVE: Lower fossil fuel heat requirements for greenhouses and residences by studying a 'bubble' covered solar salt pond (sized for a single family 2000 ft residence) as an integrated solar collector, heat storage unit, and heat source for a greenhouse.

APPROACH: A salt concentration gradient will be established to keep the pond non-convective to attain 90 C temperatures. A plastic greenhouse will cover the pond for heat retention and weather protection. Heat will be extracted by a fresh water heat exchanger. The fresh water will either be used directly in the greenhouse or warmed by a heat pump. The heat pump will also be evaluated for moving heat from the greenhouse to the pond. An energy accounting and budgeting system will be developed for correct source, flow and sink for heat at various times.

PROGRESS: An experimental solar pond was designed and previously constructed to meet all the winter heat requirements of a 186m (2000 ft) home or a 98m (1000 ft) greenhouse in Wooster, Ohio. The pond is 3.6 m deep, 8.5 m wide and 18.3 m long with a 1.8 m convective zone of 20% N(a)C1 in the bottom half and a concentration gradient that varies from 20% at 1.8 m depth to zero at the surface. The maximum recorded pond temperature in Sept. 1976 was 43.3 C (110 F). This is much lower than an expected maximum temperature of 82 C (180 F). Insufficient radiation entering the pond and excessive soil heat losses are being studied as possible reasons for not achieving higher temperatures. A plastic greenhouse with a north wall reflector covers the pond to conserve heat and protect the surface from wind, rain and debris. A computer model was developed to study the annual response of the system. Pond surface radiation was measured for different covers, reflectors, and solar angles. Salt diffusion measurements indicate that the top 2.5 cm of gradient (3800 liter) will reach a one percent concentration in 25 days. This is equivalent to 680 kg of salt per year. The gradient is maintained by pumping off surface brine and adding fresh water every 4-6 months. Analyses of greenhouse and home heating requirements, and pond draw-down rates, have been performed. Design plans are to meet heating demands with direct brine-to-water-to air heat exchangers at pond temperatures above 100 F.

SUPPORTED BY Ohio State Government

1.0288,

MECHANIZATION OF GREENHOUSE CULTURAL AND ENVIRONMENTAL SYSTEMS

T.H. Short, Ohio Agricultural Research & Development Center, *Wooster, Ohio* 44691 (OHO00576)

OBJECTIVE: Establish new technology to reduce labor cost, labor drudgery, and fossil fuel heating requirements for greenhouses.

APPROACH: Labor-aid mechanisms will be developed to reduce drudgery and increase labor efficiency of growing greenhouse crops under present cultural systems. Machinery will be developed for high population cultural systems to achieve high production of tomatoes, lettuce and other greenhouse crops. Mechanical methods of adding nighttime insulation to greenhouse covers will be developed and tested. Mechanical systems for transferring heat to a greenhouse from solar collectors and heat storages such as a solar pond will be studied and developed. Greenhouse energy sources will be integrated into workable, efficient and economic systems of crop production.

PROGRESS: A new gutter-connected greenhouse (37' x 96') was built in 1975 for Agricultural Engineering studies associated with this and other projects. Crops of rye, soybeans, tomatoes, cucumbers and lettuce have been grown to evaluate the soil uniformity. Trickle irrigation systems have been evaluated to establish a basis for future studies. study in cooperation with Horticulture has shown that a 57% heat savings is possible in glasshouses if covered by air-inflated double plastic. These same studies have shown that 85% of all greenhouse heat is used at night. The possibility of insulating a double-plastic greenhouse just at night with 4 in. of polystyrene beads is being studied. If successful this could reduce fossil fuel requirements by 80% for glasshouses and 75% for double- plastic covered greenhouses. Therefore, experimental systems are presently being developed to pump polystyrene beads into and out from between the two layers of plastic that would normally cover a greenhouse. An experimental greenhouse roof (10' x 12') has been constructed. Beads have been pumped between the plastic roof sections and removed. A major problem appears to be static charges on the polystyrene beads and greenhouse plastic. One layer of beads tends to stick to the plastic while the remainder can be removed. The static charge problem is currently being discussed with industry specialists to try to cooperatively develop a solution.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Ohio

1.0289,

SALT GRADIENT SOLAR POND DEVELOPMENT

C.E. Nielsen, Ohio State University, Columbus Campus, School of Arts & Sciences, Dept. of Physics, *190 N. Oval Dr., Columbus, Ohio* 43210 (EG-77-G-04-4155)

The objective of this study is to develop improved pond design and operation procedures so as to make the solar pond a practical heat collection and storage device. The emphasis of the project is on the following areas: (1) further test of procedures for measurement and control of transparency; (2) experimental, theoretical and numerical study of convection layer dynamics; (3) calculation and accurate measurement of perimeter heat losses; (4) continuing operation of the present Farm Science Review pond; (5) construction of a new and deeper pond for research and all-winter heating; (6) continuing collaboration with the Wooster solar pond program; (7) collection of data from non-research ponds constructed elsewhere; and (8) improved public communication. Research to date has demonstrated the stability of the salt-gradient zone and has provided adequate procedures for dealing with most aspects of solar pond design and operation. If solar ponds can be made to provide the calculated amount of winter heat, they will be the lowest cost solar heating system available. With existing construction technology, they could immediately be put to widespread use. (DOE/CS-0010)

SUPPORTED BY U.S. Dept. of Energy, Office of Conservation & Solar Applications, Div. of Solar Applications

1.0290,

RESEARCH ON SOLAR HEATING AND COOLING GREENHOUSES AND RURAL RESIDENCES

T.H. Short, Ohio State University, Ohio State University Agricultural Technical Inst., Agricultural Research & Development Center, Dept. of Agricultural Engineering, *Wooster, Ohio* 44691

This project is designed to study the feasibility of heating greenhouses with direct and stored solar energy. An especially unique aspect is the use of a solar pond for heat collection and storage, of size that will match the total winter heat requirement of a 2000 ft2 residence in Ohio and will meet the partial needs of the greenhouse. properly controlled salt concentration gradient in the pond will keep it non-convective to the point of potentially attaining and holding temperatures up to 80 or 90 degrees C. A greenhouse frame with double layer plastic will be designed to cover the pond for surface heat retention and protection from wind and rain. Heat will be taken from either the top or bottom of the solar pond via a fresh water heat exchanger.

The fresh water will either be used directly in the greenhouse or run through a heat pump to increase the temperature. The heat pump will also be evaluated as a means of cooling the greenhouse and further warming the pond on sunny days. An energy accounting and budgeting system will be developed to determine the correct source, flow and sink for heat at various points at various times. This budget system will be used as a guide to develop a total energy system of greenhouse growing.

SUPPORTED BY U.S. National Science Foundation, Unspecified Unit

1.0291,

SOLAR HEATING & COOLING DEMONSTRATION - TULSA, OKLAHOMA

Unknown, Creek Nation Housing Authority, *Tulsa, Oklahoma*

Five existing single family homes are to be connected with a solar heating and domestic hot water preheat system. The solar system is designed as an ancillary structure to be sited as dictated by the design and orientation. The ancillary structure can be designed as a carport, covered play area, storage room or other on-site uses. The one story homes to served by the solar system are approximately 1,050 square feet each.

SOLAR APPLICATION: HEATING AND HOT WATER

COLLECTOR: 234 square feet, liquid-cooled flat-plate manufactured by RAYPAK.

STORAGE: 500 gallons of water withing a 3 feet 9 inches x 6 feet inch tank behind the collector in the pre-assembled ancillary structure.

DISTRIBUTION: Forced air. Heated water from storage flows through coils that transfer the heat to air, then distributed by ducts to the living spaces.

AUXILIARY ENERGY SYSTEM: Propane-fired furnace. The furnace heats a separate coil located in the primary supply duct. A full or partial energy boost is supplied depending on storage temperature.
DOMESTIC HOT WATER SYSTEM: A 90 gallon propane-fired tank receives water preheated by passing through a copper coil in the main storage.
COOLING: Natural ventilation.
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0292,
TECHNIQUES TO INCREASE QUALITY, PRODUCTIVITY AND EFFICIENCY OF YEAR-ROUND FORAGE SYSTEMS
D.G. Batchelder, Oklahoma State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *107 Whitehurst Hall, Stillwater, Oklahoma* 74075 (OKL01627)
OBJECTIVE: Develop and evaluate hay harvesting equipment, techniques and methods to enhance solar drying. Reduce quality losses of large round hay bales during storage and determine the range of hay moisture that will cure without undue spoilage during storage of loose alfalfa hay stacks formed in compaction wagons.
APPROACH: Hay conditioning rolls, chemicals and/or heat will be applied to newly cut hay to aid in solar drying. Appropriate samples will be taken during the tests to evaluate quality. Storage conditions will be evaluated for large round bales. Bales on a 2-year storage will be sampled periodically. Plastic will be wrapped around some bales during the 'tie-out' portion of baling. If storage using plastic-wrap is feasible, equipment will be developed to mechanically apply the plastic during baling. Alfalfa hay, stacked in canopy compaction harvesting wagons, will be stored under different initial moisture conditions. Appropriate data will be taken during storage to evaluate hay quality.
PROGRESS: OBJECTIVE A: Typical hay conditioning rolls are being obtained from equipment manufacturers (rubber intermeshing, steel intermeshing, rolls with bars welded for breaking the steams, smooth steel rools covered with rubber, and smooth steel rolls). These will be used in 18-inch lengths for laboratory evaluation of their drying potential. A drive system is being developed to allow for infinitely variable speed (hydraulic motors). Stainless steel conveyor chain (1' 1' squares) will be used to feed the conditioner rolls. Two passes of material will be possible by having duplicate sets of conveyor chains and conditioning rolls. Preliminary data indicates higher leaf-stem ratio for shorter plants which suggest lower quality hay for the more mature alfalfa crop. OBJECTIVE B: Alfalfa, Bermudagrass and Forage Sorghum hay in large round bales were formed during the Summer of 1976. The bales were sampled for quality analysis and stored in the six conditions as outlined in the proposal. Weather data is being accumulated during the two year storage period. Dry matter losses occurring during storage were determined December 8, 1976. OBJECTIVE C: Sixteen alfalfa loose hay stacks were formed in June 1976. Moisture content of the hay at stacking varied from over 32% to below 16%, wet basis.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Oklahoma

1.0293,
BEEF PACKING PLANT DRYING PROCESS USING SOLAR ENERGY
G.H. Brusewitz, Oklahoma State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *107 Whitehurst Hall, Stillwater, Oklahoma* 74075 (7091-20530-001-A(1))
OBJECTIVE: Design, construct and test scale model of solar waste processing system with mechanical dewaterer, solar still, solar dryer, and desiccant bed for energy storage. Study heat and mass transfer process as affected by experimental conditions.
APPROACH: Collect packinghouse beef paunch, encourage fermentation to dewater and provide heat, study methods to mechanically dewater and separate solids. Purify liquid in solar still. Operate direct radiation solar dryer for separated solids. Study heat and mass transfer. design desiccant bed for drying solids in periods of low insolation and regenerate during high insolation. Determine amibent conditions to best use capacilities of desiccant. Compare drying via desiccants with direct solar drying. Recommend best systems for feed from paunch material.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Florida - Antilles Area

1.0294,
DRYING FOOD MATERIALS BY DIRECT APPLICATION OF SOLAR ENERGY
G.H. Brusewitz, Oklahoma State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *107 Whitehurst Hall, Stillwater, Oklahoma* 74075 (OKL01652)
OBJECTIVE: Demonstrate the use of a directly heated, enclosed solar dryer for drying food materials during processing. The objectives for the first year are to: Design, construct and test laboratory-size, direct-heated, enclosed solar dryers to dry high moisture food materials. Determine the drying characteristics of the material (initially this would be paunch) as a function of time, temperature, operating procedures, and paunch constituents. Investigate the handling aspects of the material in order to determine the need for a mechanical stirring mechanism and/or perforated bottom to insure maximum drying. Determine the conditions, both optimum and limiting, under which the dryer will operate in an environmentally acceptable procedure.
APPROACH: A direct heatd, enclosed solar dryer will be designed based on the information in the literature. Beef packing plant paunch, a waste product in the past, will be used as an example of a high-moisture, low-value food processing plant material. The drying rate of this paunch material will be measured to predict the operation of a pilot-size solar dryer in future years. Operating procedure variables expected to have major influence are material depth, frequency of paunch filling and dried material removal, and initial and final moisture content.
SUPPORTED BY Oklahoma State Government

1.0295,
ANIMAL WASTE MANAGEMENT WITH POLLUTION CONTROL
A.F. Butchbaker, Oklahoma State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *107 Whitehurst Hall, Stillwater, Oklahoma* 74075 (OKL01484)
OBJECTIVE: Further develop animal waste management systems in the area of: collection, transport, and management of wastes, treatment, and conditioning of wastes, and economic, biological, and physical analysis and integration of above systems.
APPROACH: Determine the physical, thermal, and rheological properties of solid and slurry beef animal wastes. Analyze alternative beef feedlot layouts and waste handling systems to determine minimum cost systems. Determine effectiveness of oxidation ditch treatment of beef animal wastes. Determine the costs and returns of current and proposed methods of handling animal wastes from selected confined animal feeding operations by using budgeting, linear programming, and other benefit-cost analysis techniques.
PROGRESS: A rotating conical screen separator was developed which effectively removed hair and large grain particles from a beef manure slurry in an oxidation ditch underneath a slotted floor. The device was self-cleaning and required low energy inputs. The total solids of the separated solids ranged from 70,000 mg/1 to 105,000 mg/1 depending upon rotational speed and influent flow rate for an influent solids concentration of 38,000 mg/1. Anaerobic digestion studies of beef and swine waste continues. The separation of the solids by sedimentation and coagulation is being examined. A beef waste handling system for the slotted floor beef confinement building is being installed. It consists of a cable scraper, solids separator, and dewatering by using the solar still principle. The dried material will be used in a ration for ruminant animals.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Oklahoma

1.0296,
DRYING AND CURING PEANUT PODS WITH SOLAR ENERGY
B.L. Clary, Oklahoma State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *107 Whitehurst Hall, Stillwater, Oklahoma* 74075 (7090-11021-003-A)
OBJECTIVE: Develop and evaluate practical systems for drying and curing peanut pods using energy from low-cost solar collectors.
APPROACH: During the first phase of the research, a low-cost solar collector will be used to provide heat for drying peanuts. Designs will be developed for a control system to maintain optimum drying conditions during high incident solar radiation. Simplification of the collector and reduction of the cost per heat unit collected will be used to evaluate the collector. A simulation model will be developed to expedite the evaluation of the proposed drying system. The model will be tested by comparing model results with those from operation of the solar peanut drying system.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0297,
DRYING AND CURING AGRICULTURAL PRODUCTS USING SOLAR ENERGY
B.L. Clary, Oklahoma State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *107 Whitehurst Hall, Stillwater, Oklahoma* 74075 (OKL01601)
OBJECTIVE: Develop and evaluate practical systems for drying and curing peanut pods using solar energy. Specific objectives are: Design and test solar collector. Determine curing conditions for optimum utilization of solar energy, and develop energy storage systems.
APPROACH: The first year of the study proposes design, construction and testing of a solar collector to heat ambient air for direct use in drying peanut pods. Optimum operating conditions will be determined for optimum kernel quality and use of solar energy. Effects of cycling drying air temperature on a diurnal basis as well as reducing maximum drying temperatures as pod moisture content decreases will be studied. Systems and control mechanisms for varying air flow rate through the collector and drying bed as incoming solar radiation changes will be developed. Methods for storing solar energy during periods when incoming energy is not available will be evaluated and developed.
PROGRESS: The primary objective of this research was to develop and evaluate practical systems for drying and curing peanut pods using energy from low cost solar collectors. Analysis of variance of test data revealed no significant difference between percent sound split of the peanut kernels for various air flow rates tested. However, temperature varied inversely with flow rate for equal collector sizes resulted in low drying rates, all of which were less than 0.5% w.b. per hour. Low drying rates coupled with experimental error are expected to be the major cause for non-significance between treatments. Analysis of variance did indicate a significant difference at the 95% confidence level between days with considerable differences in solar radiation intensities. Similar results were obtained for laboratory cyclic drying. USDA grades and percent sound splits from tests on peanut pods dried during the solar test were comparable with those dried conventionally. But, no attempt was made to determine any effect on flavor quality. This study has revealed that with the present collector design, 50% of solar energy available during an average drying season in Oklahoma can be efficiently utilized for curing peanut pods. This would require a design of collector size three to five times the dryer floor area assuming depth of 1.22 m to 1.83 m and dryer flow rates of 18 m 3/min/m .
SUPPORTED BY Oklahoma State Government

1.0298,
DRAFTING AND DISPLAY SERVICE
G.W. Mahoney, Oklahoma State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *107 Whitehurst Hall, Stillwater, Oklahoma* 74075 (OKL00734)
OBJECTIVE: Provide graphic and engineering services to the Oklahoma agricultural experiment station staff.
APPROACH: Under the project, drafting service, preparation of illustrative material, engineering consultation, design and supervision, and similar services of the agricultural engineering department are provided to individuals and departments within the agricultural experiment station, as related to approved or pending research projects sponsored by the experiment station.
PROGRESS: Under this project, drafting service, preparation of illustrative materials, engineering design, engineering consultation and supervision from the Agricultural Engineering Department are provided to various departments and activities of the Agricultural Experiment Station. Services were provided to eight departments and included 1170 items. Drafting and related time totaled 1755 hours. Engineering design, consultation time and time spent in supervisory capacity was approximately 300 hours. Total time devoted to this project comprised 2055

hours. Completed Plans and Consultations for This Year: Solar Greenhouse Plans, Roadway Layout, Soil Bins, Building Plans for Muskogee Res. Sta., Peanut Drying Sheds, Topographic Map-O.S.U.R.S. Areas.
SUPPORTED BY Oklahoma State Government

1.0299,

FACTORS AFFECTING ORNAMENTAL PLANT PRODUCTION

C.E. Whitcomb, Oklahoma State University, Agricultural Experiment Station, Dept. of Horticulture, *107 Whitehurst Hall, Stillwater, Oklahoma* 74075 (OKL01548)

OBJECTIVE: Determine the effects of slow release fertilizer in the rooting medium on rooting and subsequent growth of cuttings. Develop slow release fertilizer system for nursery stock. Evaluate currently available hericides for weed control in nursery stock. Study the effects of container size and plant growth on plant performance in the nursery and in the landscape. Determine the optimum shade, fertilizer level combination for production of shade requiring landscape shrubs.

APPROACH: Studies will be conducted at the OSU nursery which is maintained similarly to a commercial nursery. All studies will begin near the frost-free date for this area and allowed to grow for at least one full growing season and evaluated for marketability. In evaluating slow release fertilizers and container size, a portion of the plants will be planted in the field and maintained as in a landscape following the production phase. It is theorized that these conditions during production will have a dramatic effect on the plant in the landscape.

PROGRESS: A solar heated greenhouse 26' X 72' was designed and constructed. Energy is collected in the double poly covering using mist lines and stored in a sand bed beneath the floor. Early results suggest it can reduce the fossil fuel required by 60 to 80%. A series of studies were conducted to determine if any herbicides can be used safely to control weeds on a greenhouse floor. Hyvar X (bromacil) appears safe at rates of 15 or 30 lbs. aia. However, Pramitol 5 PS pellets and Pramitol (prometone) spray were devastating at rates as low as 10 lbs. aia. One half pint milk cartons were used as bottomless containers on raised wire bench out of doors. Quercus shumardi, Betula nigra, Pinus thunbergi, and Carya illinoensis were planted April 13 and grown with 0, 1000, 2000 or 3000 lbs. of N/A/yr. from 18-6-12 Osmocote. All seed germinated and responded quickly to the fertilizer in the growing medium. After 6 months pines were 10 to 12' tall and oaks were about 4'. Transplanting from the milk cartons to containers or the field was done in 102 F weather with no leaf drop, wilting or losses. Eleven shrub species were grown in shade of 0, 25, 30, 47, 63 and 73% and 3 fertility levels. Most species grew best in the 47 or 63% shade. Most species were able to tolerate hig (Text Truncated - Exceeds Capacity)

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Oklahoma

1.0300,

SOLAR HEATING AND ENERGY CONSERVATION FOR GREENHOUSES

C.E. Whitcomb, Oklahoma State University, Agricultural Experiment Station, Dept. of Horticulture, *107 Whitehurst Hall, Stillwater, Oklahoma* 74075 (OKL01690)

OBJECTIVE: Develop and field test economical solar heated greenhouses containing their own heat storage system until the basic design criteria are stabilized. Experiment with pot and air temperatures until the minimum allowable soil and air temperature combinations are determined for the major horticultural crops. Develop a heat conversion system for nighttime operation until a heat loss reduction of 7 is routinely achieved. Develop the controls, sensors and actuators needed to secure optimum efficiency from the solar heating and storage system.

APPROACH: An improved greenhouse incorporating the lessons from the initial greenhouse will be built and instrumented. The original greenhouse will be converted to a gas heated greenhouse and used for comparison purposes. Grow an assortment of cultivars of the major greenhouse crops (Chrysanthemums, Poinsettias, tomatoes, and others) with known greenhouse temperature requirements in both the solar and gas heated greenhouses. A programmable controller will be installed in the improved greenhouse. The controller allows flexible rearrangement of the connections between inputs (thermostats, pressure sensors) etc.
SUPPORTED BY Oklahoma State Government

1.0301,

SOLAR HEATING AND COOLING DEMONSTRATION - ASHLAND, OREGON

V.I. Oredson, (No Performing Organization Reported), Ashland Oregon, *Oregon*

PROJECT SUMMARY: The project involves the application of solar space heating and domestic hot water preheating system to a two bedroom, 1,350 square foot, one story residence. Daytime activities areas are located on the south side of the house to take advantage of the light and the heat. The bedrooms are located on the north side of the house. A south-facing greenhouse supplies light and heat to the interior spaces. All south-facing windows are shaded from the summer sunlight to reduce heat gains.

SOLAR APPLICATION: Heating and hot water.

COLLECTOR: 320 square foot liquid-cooled flat-plate manufactured by West Coast Solar.

STORAGE: 2,000 gallons of water within an insulated steel tank buried beneath the house.

DISTRIBUTION: Forced air. Hot water circulates through coils within the electric furnace. Air is warmed as it passes through coils for distribution by duct to the living space.

AUXILIARY ENERGY SYSTEM: Electric furnace. The furnace provides total or supplemental heat as required to the forced air system.

DOMESTIC HOT WATER SYSTEM: A heat exchanger inside the storage tank preheats the water before it enters a conventional 95 gallon water heater.

COOLING: Natural ventilation.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0302,

ENERGY CONSERVATION SYSTEM FOR THE FOOD INDUSTRY

J.K. Nwude, Drexel University, School of Engineering, Dept. of Mech Engin, *32nd & Chestnut Sts., Philadelphia, Pennsylvania* 19104

Description: It is proposed that an energy conservation system that employs water-source heat pump, energy reclamation loop and solar heating and cooling supplement (HP-RL-SS System) be studied by methods of mathematical analysis and computer simulation for application to Food Processing Industries. The study is aimed at determining the effects of sub-system parameters for the purpose of technical performance prediction and optimal system design. The program consists of carrying out an energy audit of food processing facilities to establish the energy requirements for the processes, products, space conditioning, wastes and exhausts; developing a mathematical and computer simulation model for predicting the performance of HP-RL-SS System; and testing and implementing the model by designing and evaluating a HP-RL-SS System for application to the food processing facilities of Campbell Soup Company.

Addenda: Estimated calendar year funding reported as 1974 $12,000; 1975 $16,000. This project is also supported by: Drexel University.

SUPPORTED BY U.S. National Science Foundation, Div. of Engineering

1.0303,

ENERGY CONSERVATION SYSTEMS FOR GREENHOUSES

R.A. Aldrich, Pennsylvania State University, University Park Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *201 Shields Bldg., University Park, Pennsylvania* 16802 (PEN02194)

OBJECTIVE: Design, build and evaluate thermal insulation systems for use in greenhouses. Design, build and evaluate a greenhouse structure and environmental control system for efficient use of solar energy. Design, build and evaluate solar energy storage and recovery systems for use in greenhouses.

APPROACH: Materials with potential for reducing heat loss from greenhouses during dark periods will be evaluated by sample testing and analysis. Structural panels with high thermal resistance (R●10) will be fabricated and tested to determine their mechanical and heat transfer properties. Structural systems will be designed that will satisfy solar energy transmission requirements during light periods and heat conservation practice during dark periods. The structural and environmental systems will be evaluated as greenhouses based on their potential for conserving thermal energy, for using solar energy for heating, and for crop production. Solar energy storage and recovery systems will be designed, built and tested to determine their potential for conserving fuel and providing for environmental control in greenhouses.

PROGRESS: Four 20' x 20' experimental greenhouses have been completed. Three are fiberglass glazed, one is glazed with a double wall acrylic extrusion. All units will have internal thermal shells for night use to reduce energy consumption. House 1 has internal solar energy collection with rock storage. House 2 had external solar energy collection with water storage. House 3 has combined internal and external solar energy collection with rock storage. House 4 will use heat pump assisted combination internal and external solar energy collectors with rock storage. Tomatoes, cucumbers, lettuce and radishes will be grown in raised beds to indicate effects of microclimates created by the various energy systems on plant growth and appearance. Sixty seven materials have been tested in the modified hot box to determine their overall heat transmission values. Four materials have been installed and tested in the glass greenhouse. A reflective air inflated polyethylene tube system provided reasonable heat loss resistance but amounts of shading was unacceptable. Two curtains of spun bonded polyolifin fabrics results in low heat transfer coefficients and are easily moved for day storage.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Pennsylvania

1.0304,

ENERGY CONSERVATION SYSTEMS FOR GREENHOUSES

J.W. White, Pennsylvania State University, University Park Campus, Agricultural Experiment Station, Dept. of Horticulture, *201 Shields Bldg., University Park, Pennsylvania* 16802 (7092-20690-003-A2)

OBJECTIVE: Conserve energy in greenhouses through utilization and storage of solar energy and reduction of night time radiant energy losses.

APPROACH: Develop, test and evaluate reflective screens to reduce conductive, covective, and radiative heat losses from greenhouses at night. Screening materials will include a group of hybrid fabrics of bonded aluminum foil and cloth that can be made with one or two layers of foil backed by vinyls or polyethylenes. Test and evaluate certain salt hydrate solutions for use as thermal storage materials, and develop technology for transfer of solar energy into and from these storage materials. Investigate methods of altering the reflecting and transmission characteristics of glass to improve its use as a greenhouse cover.

PROGRESS: Four 20' x 20' experimental greenhouses have been completed at the Rock Springs Agricultural Research Center of The Pennsylvania State University. Three will have solar collectors, storage and reuse systems in operation during the late winter and early spring period. Tomatoes, cucumbers and radishes will be grown in the greenhouses. These plants have been started and will be moved into the houses in mid-January. All houses will have internal thermal shells for night use to reduce energy consumption. House number 1 has internal collection with rock storage. House number 2 uses external collection with water storage. House number 3 will use a heat pump assisted combination of internal and external collection with rock storage. House number 4 has combined external and internal collection with rock storage. Several new materials have been tested in the modified hot box to determine their heat transfer characteristics. Two new thin spun bonded polyolifin thermal blanket materials are undergoing full scale tests in the glasshouses. Results of initial tests with these materials are very promising.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0305,

HEATING COMMERCIAL GREENHOUSES WITH SOLAR ENERGY

J.W. White, Pennsylvania State University, University Park Campus, Agricultural Experiment Station, Dept. of Horticulture, *201 Shields Bldg., University Park, Pennsylvania* 16802 (7004-20690-017-A)

OBJECTIVE: Design, test, and evaluate greenhouse structures, various greenhouse solar heating systems, and environmental control systems for efficien-

cy of use of solar energy for greenhouse heating and plant growth.
APPROACH: Construct a seventh greenhouse of two-barrel vault design with a double-layer air inflated polyethylene cover, using one greenhouse as a control with a standard fossil-fuel heating system, compare various active and passive solar heating systems in the other six. Vary the solar systems so as to compare solar collection external and internal to the greenhouse, use of solar heated water or solar heated air, and rock and water heat storage systems. Install thermal blankets either thin (L 6 mil) or thick (G 6 mil), and compare their effectiveness. Monitor energy use and environmental parameters and correlate with system designs and evaluate plant response to the environments produced by each solar heating system.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0306,
SOLAR HEATING AND COOLING DEMONSTRATION - PHILADELPHIA, PENNSYLVANIA
Unknown, University of Pennsylvania, Graduate School, *203 Logan Hall, Philadelphia, Pennsylvania* 19104
PROJECT SUMMARY: The project involves the modification of a three story 3,942 square foot single family dwelling for a solar preheating system and domestic hot water. To reduce heat loss and infiltration all doors and windows are recaulked. The collectors are supported by a structural steel frame on the roof and are connected by transport piping to a storage and tank located in the basement.
SOLAR APPLICATION: Heating and Hot water.
COLLECTOR: 584 square feet liquid-cooled flat-plate manufactured by PPG Inc. and International Environment Corp. The collectors are automatically drained to prevent freezing.
STORAGE: 1,500 gallons of water within two insulated cylindrical tanks 5' diameter by 5' high located in the basement.
DISTRIBUTION: Forced air. Hot water from storage is circulated through a water to air heating coil in the existing ductwork. The air blown over the coil is warmed and distributed by ducts to the occupied areas.
AUXILIARY ENERGY SYSTEM: Oil-fired furnace. The furnace provides supplemental heat as required to the forced air system.
DOMESTIC HOT WATER SYSTEM: A heat exchanger within the main storage tank preheats the domestic hot water supply and possibly is reheated by a conventional water heater.
COOLING: Natural ventilation.
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0307,
SOLAR HEATING AND COOLING DEMONSTRATION - NEWPORT, RHODE ISLAND
Unknown, Church Community Corp., *Newport, Rhode Island* 02840
PROJECT SUMMARY: The project combines a 1,400 square foot single family detached dwelling with a solar heating and domestic hot preheating water system. Collectors form an integral part of the south-facing roof. To reduce heat losses additional insulation is placed in the floors, walls, and ceiling. Also winter heat loss is reduced by the use of storm windows. To accommodate the added wall insulation 2 inch by 6 inch studs spaced 24 inches on center are used.
SOLAR APPLICATION: HEATING AND HOT WATER
COLLECTOR: 432 square feet air-cooled flat-plate manufactured by Church Development Corp. Air flows through a duct formed by two layers of a double plastic panel.
STORAGE: 600 cubic feet of 2 1/2 inch diameter rock within an insulated concrete bin located in the basement.
DISTRIBUTION: Forced air. Air is blown through the rock storage bin by an auxiliary blower in the primary supply duct. A blower in the furnace distributes the hot air to living spaces through supply ducts.
AUXILIARY ENERGY SYSTEM: Oil-fired furnace. The furnace provides supplemental heat to the solar energy system as required.
DOMESTIC HOT WATER SYSTEM: A finned copper coil in the rock storage bin preheats the domestic water supply prior to entering a 30 gallon conventional water heater.
COOLING: Natural ventilation.
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0308,
SOLAR ENERGY FOR HOME HEATING
W.H. Allen, Clemson University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Long Hall, Clemson, South Carolina* 29631 (SC00307)
OBJECTIVE: Determine the daily energy requirements of two solar heated structures; the effectiveness of the solar energy collectors; the adequacy of the architectural design and solar heating systems in achieving a favorable living environment; the productive potential of the solar-heated greenhouse for supplying all or part of the food supply of the structure's occupants; the cost and energy savings (including coasts of construction, heating and cooling, maintenance and food), if any, resulting from the designs used in the structures.
APPROACH: Two solar heated houses, one earth insulated and the other with an attached greenhouse, will be constructed. A study will be made of the design, construction methods, and energy efficiency of the structures. Instrumentation will be installed to monitor heat loss and other environmental factors prior to occupancy. Studies will continue during occupancy.
SUPPORTED BY South Carolina State Government

1.0309,
SOLAR ENERGY AND WASTE HEAT UTILIZATION WITH GREENHOUSE/RESIDENCE COMBINATIONS
T.E. Bond, Clemson University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Long Hall, Clemson, South Carolina* 29631 (7092-20691-012-A2)
OBJECTIVE: Develop, test, and evaluate designs for greenhouse/residence combinations that will conserve energy by mutual exchange and use of heat and insulation between the two structures, optimize use of solar energy for supplemental heat, and produce more food on less land.
APPROACH: Use existing research knowledge and theory to develop: effective methods of solar energy collection, utilization, and storage in greenhouses; economical systems for mutual exchange of excess heat between a combined greenhouse and residence; and means of utilizing the potential of mutual insulation of the combined greenhouse and residence. Develop at least three design concepts for combining greenhouses and residences to optimize the use of solar energy as supplemental heat, and develop construction and operational plans for the most promising design concept. Build a prototype for test and evaluation, and revise experimental features that will improve energy conservation, solar energy utilization, cost effectiveness and social and aesthetic acceptability.
PROGRESS: Construction plans were completed for two greenhouse-residence combination. The College of Architecture plan includes an attached greenhouse, but does not have a separate solar collector. The Rural Housing Research Unit plan has 1336 ft of solar heated air collector, 1200 ft of rock storage, and a greenhouse with 352 ft of floor area. Construction has started on the RHRU plan and it will be instrumented and evaluated for one year. The Horticulture Department of Clemson University will plan and monitor the greenhouse production during the same period. The College of Architecture will supervise construction. A contract was completed with Mechanics Research, Inc. of Los Angeles for provision of a dynamic computer analysis of both greenhouse-residence prototypes. This analysis will be used for performance evaluation and for indicating potential improvements in design and operational performance.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0310,
SOLAR ENERGY AND WASTE HEAT UTILIZATION WITH GREENHOUSE/RESIDENCE COMBO
D.O. Ezell, Clemson University, Agricultural Experiment Station, Dept. of Horticulture, *Long Hall, Clemson, South Carolina* 29631 (7007-20690-202-A)
OBJECTIVE: Develop, test, and evaluate designs for greenhouse-residence combinations that will conserve energy and optimize use of solar energy for supplemental heating of both structures, and provide space for production of family vegetable needs.
APPROACH: Complete construction of two additional prototype residences with attached greenhouses. Instrument, test, and evaluate these prototypes and continue tests of first prototype to determine the value of attached greenhouses in modifying the heating and cooling needs of associated residences and in supplying family food needs. Develop optimum vegetable production program for the greenhouses. Refine, modify, and improve plans for greenhouse-residence combinations based on construction feedback and costs, operation of mechanical systems, and on greenhouse food production data.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0311,
SOLAR HEATED GREENHOUSE-RESIDENCE COMBINATIONS
Unknown, Clemson University, Graduate School, *Tillman Hall, Clemson, South Carolina* 29631
To construct two prototype houses equipped with lowcost solar heated air systems; one would be a greenhouse-residence combination, and the other a partially underground residence. The prototypes will be built on Clemson University property in accordance with designs prepared by the Rural Housing Research Unit of the Agricultural Research Service, U.S. Department of Agriculture. The design for greenhouse-residence combination was developed under a grant from Energy Research and Development Administration (ERDA).
The special feature of a greenhouse-residence combination is the storage of excess solar energy entering a greenhouse to heat both the greenhouse and the residence. The greenhouse also helps to insulate the residence, and the heat escaping from the residence helps heat the greenhouse. On the other hand, the particular advantage gained by building a residence partially underground is the good insulation provided by underground walls.
The purpose of the prototypes will be to: (a) provide research facilities for study, investigation, evaluation and technology improvement of (i) residence solar heating systems, (ii) methods of collecting, storing and utilizing solar energy for night heating of greenhouses, (iii) planting practices for maximum greenhouse production, (iv) methods for conserving energy, and (v) architectural design considerations for solar heated residences with attached greenhouses, and residences that are partially underground; (b) provide teaching, research and demonstration facilities for students; and (c) provide public demonstration of residence solar-heating, utilization of an attached greenhouse and partially underground structure and increase public awareness, acceptance and use of solar energy for home space heating, as well as use of greenhouse for home food production.
SUPPORTED BY U.S. Appalachian Regional Commission

1.0312,
EVALUATION OF SOLAR ENERGY AS A SOURCE OF TEXTILE PROCESS WATER HEATING
J.C. Hester, Clemson University, School of Engineering, Dept. of Mech Engin, *Rhodes Research Bldg., Clemson, South Carolina* 29631
Technical and economic factors governing the use of solar energy in the textile industry were covered. The results indicate the merits, both technical and economic, of various solar types to satisfying various textile industry process water needs.
SUPPORTED BY U.S. Dept. of Energy

1.0313,
BUILDING AND UTILITY SYSTEMS TO REDUCE COSTS OF HOUSING FOR LOW-INCOME RURAL FAMILIES
T.E. Bond, Clemson University, U.S. Dept. of Agriculture Agricultural Research Service, Rural Housing Res, *Long Hall, Clemson, South Carolina* 29631 (7708-14730-001)
OBJECTIVE: Reduce costs of components of building systems, including construction methods and materials, utilities and waste handling to lower initial and operational costs of housing for low-income rural families while improving livability and acceptability.
APPROACH: Develop innovative structural systems, construction techniques, and utilities, including heat-

ing, cooling, plumbing and electrical systems, that have potential for reducing initial or operational costs of housing structures, Test and evaluate these in laboratory and in prototype structures (in cooperation with other housing agencies). Investigations will include panelized construction techniques, new building materials, optimum mixes and combinations for building blocks and wall panels utilizing inexpensive or waste materials, heating and cooling with various forms of energy including solar energy, simplification of plumbing systems and improvement of waste control systems.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0314,
SOLAR HEATING AND COOLING DEMONSTRATION - GREENVILLE, SOUTH CAROLINA
Unknown, Helio Thermics Inc., *Greenville, South Carolina*
PROJECT SUMMARY: The project is a low-cost one story single family dwelling that uses an attic space as the solar collector. The 1,080 square foot wood frame house is well insulated, and an air space separates the solar heated, black painted, plywood floor of the attic from the ceiling. In winter the south-facing glazed roof collects heat in the unventilated attic. The heated air is removed to rock storage located in a crawl space under the floor. A continuous operable ridge vent ventilates the attic in the summer.
SOLAR APPLICATION: HEATING AND COOLING
COLLECTOR: 412.5 square foot air-cooled flat-plate manufactured by Helio Thermics, Inc. The attic collector admits solar radiation through a transparent fiberglass glazed southern roof to a black painted plywood attic floor.
STORAGE: 1,080 cubic feet of one and one-half inch rock are located in a 1 ft. by 27 ft. by 40 ft. crawl space. At 50 degrees F, 20 BTU's are stored per cubic foot of rock.
DISTRIBUTION: Forced air. A thermostatically controlled fan on the ground floor circulates attic heated air to rock storage. The heat is then distributed radiantly to the living space. A manually operated ridge vent controls ventilation.
AUXILIARY ENERGY SYSTEM: Gas furnace located on the first floor between the fan and rock storage. The furnace supplies back-up heat whenever heat from the storage is insufficient.
DOMESTIC HOT WATER SYSTEM: Domestic hot water is heated by a conventional gas water heater.
COOLING: Heat built up in rock storage during the day is removed by venting through the attic space at night.
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0315,
FARMSTEAD ELECTRIC POWER USE AND SAFETY
M.A. Hellickson, South Dakota State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Brookings, South Dakota* 57006 (SD00483)
OBJECTIVE: Study the time and amount of electrical energy used within buildings and within farmsteads. Develop design criteria for wires, entrance switches, & overcurrent devices based on actual load rather than maximum demand, or connected load. Evaluate the potential of expanding existing electrical systems if mechanization is initiated. Evaluate the handling of power failures in environmental control systems, alternatives will be considered, such as stand-by generators automatically controlled doors.
APPROACH: Actual livestock producers will be used as cooperators. Installation of equipment and instrumentation will be installed in order to secure the most reliable information and data possible. Attempts will be made to secure livestock cooling information, as well as heating. The data secured will be compared and correlated with reliable existing livestock requirements such as in the case of a power outage. Laboratory studies will be conducted under controlled conditions to simulate seasonal conditions. This will secure initial information to further test under field conditions. Some installations will be made on University owned farms, such as the Dairy Unit.
PROGRESS: Air flow rates of 450 to 475 cfm per ton of hay were most efficient for drying package handled hay with an initial moisture content of 40 to 50 percent. Several stacks, formed with commercially available hay handling systems may be dried with a multistock drying system. Time clock air flow control provides cheaper and faster hay drying. Drying time is affected by time, relative humidity, stack density and air flow rate with time accounting for 81% of the variation in drying rate. Research has been initiated to evaluate using solar energy to supplement cold air drying of packaged hay stacks employing time clock air flow control. Evaluation of five types of low-temperature rise, low cost solar collectors mounted on the southern two-thirds of a circular shelled corn drying bin revealed that bare sheet collectors can be as efficient as plastic-covered ones. Comparison of solar supplemented and traditional low temperature and relative humidity revealed an approximately 26% decrease in energy requirements for the solar supplemented system. Research has been initiated to perform a computer simulation of the energy requirements and economics involved for various insulation, ventilation, heating and climatic interactions encountered in livestock housing.
SUPPORTED BY South Dakota State Government

1.0316,
SOLAR ENERGY GRAIN DRYING (SOUTH DAKOTA)
M.A. Hellickson, South Dakota State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Brookings, South Dakota* 57006 (3090-15707-007-A)
OBJECTIVE: Determine the economic and technical feasibility of using solar energy to supplement or replace other fuels in drying grain.
APPROACH: Conduct research on the application of solar energy for drying corn. Compare five types of low-cost solar collectors all mounted on the south two-thirds of a circular drying bin. Measure drying rate and evaluate effectiveness of collectors on basis of temperature rise and measured air flow. Compare efficiency and cost of drying corn in solar-supplemented drying bins with that of conventional low temperature drying systems.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Kansas - Nebraska Area

1.0317,
CROP DRYING AND SPACE HEATING WITH SOLAR ENERGY
M.A. Hellickson, South Dakota State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Brookings, South Dakota* 57006 (3090-15702-019-C)
OBJECTIVE: Determine the technical and economic feasibility of using solar energy for drying crops and heating agricultural buildings.
APPROACH: A multipurpose solar energy system with a solar collector and a reflective intensifier will be designed, built and tested. The collector will involve a relatively small area, but will be enhanced by a manually focused, curved reflector of an area 5 times that of the collector. The system will also include a thermal storage with capacity to store solar energy overnight. The solar system will be tested for drying shelled corn and hay and for heating of agricultural buildings in the winter months.
PROGRESS: South Dakota State University - A solar-energy-intensifier system was designed, developed and used for drying shelled corn. This system is currently being adapted by the addition of a thermal energy storage and a recirculating air system for use in agricultural space heating.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Kansas - Nebraska Area

1.0318,
SOLAR ENERGY SYSTEM TO HEAT AIR FOR SWINE SHELTERS AND GRAIN DRIERS
M.A. Hellickson, South Dakota State University, Agricultural Experiment Station, Dept. of Agricultural Economics, *Brookings, South Dakota* 57006 (7003-20400-015-A)
OBJECTIVE: Develop design criteria for a multi-purpose, diurnally-tracking solar intensifier to improve the energy collector system for swine shelter heating and corn drying.
APPROACH: Design and build a solar energy system, consisting of two-sided collector, a diurnally tracking, seasonally adjusted curved reflector and a native stone heat sink. Test system on swine shelters and on corn drying. Obtain system performance under local conditions and determine economic feasibility for simple and multiple use.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Mid Atlantic Area

1.0319,
ENERGY EFFICIENCY AND UTILIZATION IN AGRICULTURAL PRODUCTION
M.A. Hellickson, South Dakota State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Brookings, South Dakota* 57006 (SD00754)
OBJECTIVE: Evaluate systems for more efficient use of electricity, fossil fuels, and other energy sources for agricultural production. Determine the energy requirements for performing selected agricultural operations in South Dakota. Investigate methods of substituting energy sources, such as, solar and wind, for agricultural systems currently using conventional energy sources. Study the effects of management and control on energy use for agricultural production.
APPROACH: Cold air crop drying and solar supplemented crop drying studies will be conducted on the Agricultural Engineering Farm. Low temperature, low cost solar collectors will be investigated as a source of supplemental heat for confinement livestock buildings. Work will be performed to develop a multi-purpose solar-intensifier-thermal storage system for agricultural uses.
PROGRESS: A computer simulation model, based on required ventilation rates, building characteristics and livestock environmental considerations, was developed. For Brookings, South Dakota climatic conditions an overall thermal resistance value of approximately 12 Hr-ft F/Btu is optimum at current energy and insulation prices. Data have been developed on energy costs for typical months of operation and for the effects of livestock density and environmental temperature. A $45,001 research grant was received from ERDA to study a solar energy-intensifier-thermal storage system for drying agricultural products and for agricultural space heating. Studies of selected type of low cost, low temperature rise solar collectors, mounted on the southern two-thirds of conventional shelled corn drying bins, indicate that bare collectors can be as efficient as covered flat-plate collectors. Economics and energy savings have been noted for solar supplemented versus conventional low-temperature corn drying. Data have been collected on the performance of three geometric configurations of low cost, low-temperature rise solar collectors used to provide supplemental heat for a closed confinement beef building.
SUPPORTED BY South Dakota State Government

1.0320,
IMPROVING LARGE DAIRY HERD MANAGEMENT PRACTICES
R.K. McGuffey, South Dakota State University, Agricultural Experiment Station, Dept. of Dairy Science, *Brookings, South Dakota* 57006 (SD00860)
OBJECTIVE: Investigate ways of increasing the efficiency of producing dairy replacements in large herds. Improve animal performance and increase labor efficiency.
APPROACH: Various designs of calf hutches will be studied to determine the most efficient for providing added heat from solar energy. Calves three days of age will be housed in regular or solar-heated calf hutches and weight gain, feed intake and health determined. Physiological adaptation of young calves to extreme temperatures will be studied. Four free stall surfaces will be compared as to cow utilization and preference as well as labor requirements for cleaning and maintenance.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, South Dakota

1.0321,
WIND ENERGY FOR AGRICULTURAL APPLICATIONS
L.R. Verma, South Dakota State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Brookings, South Dakota* 57006 (SD00796)
OBJECTIVE: Calculate the wind energy available at selected sites in SD. Study the intensity and variation in this energy on a daily and monthly basis. Study the relative potential of wind energy as compared to other alternate energy sources. Evaluate the combined potential of wind and solar energies at selected sites in South Dakota. Investigate the potential of wind energy for agricultural applications.

APPROACH: The main thrust will be toward the feasibility of wind energy use for agricultural application, such as, crop drying, grain drying, and space heating. Existing climatological data at various locations in SD. will be evaluated for wind energy potential; including wind variation studies. Some specific analysis will be made on the availability of wind power from data. The total wind energy flux passing unit area for each month of the year, average daily wind energy flux, the distribution in time of the available wind energy, number of hours per month with wind speeds adequate for effective wind energy conversion, details about the incidence and duration of calm periods. Results obtained to be used in combination with available solar energy information to evaluate the combined potential of wind and solar energies in SD.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, South Dakota

1.0322,

SOLAR-ELECTRIC CROP DRYING DEMONSTRATION

W.H. Peterson, South Dakota State University, School of Biological & Agricultural Sciences, *Brookings, South Dakota* 57006

This project is to build and demonstrate a solar-electric corn drying bin.

SUPPORTED BY South Dakota State Government

1.0323,

DESIGN, CONSTRUCTION, INSTRUMENTATION AND EVALUATION OF A DEMONSTRATION/ RESEARCH SOLAR HOUSE

L.E. Sissom, State University & Community College System of Tennessee, Tennessee Technological Unviversity, School of Engineering, Dept. of Mech Engin, *P.O. Box 128A, Cookeville, Tennessee* 38501

DESCRIPTION: The objective of this program is to design, build, instrument and evaluate the performance of a demonstration/research solar house. Envisioned is a 3-bedroom, speculative-type house, having 1800-2000 square feet of living space, with a full, unfinished basement (for instrumentation) and ample outdoor space for possible property-line-screen solar collectors. The project is now in its formative stage. Preliminary design of the house will be complete with heating configuration adopted by the time of publication of this survey.

ADDENDA: Estimated calendar year funding reported as 1975 $128,000. This project is also supported by: Tennessee Technological University and Tennessee State Government, Energy Office.

SUPPORTED BY U.S. National Science Foundation, Unspecified Unit

1.0324,

INVENTORY OF CURRENT ENERGY RESEARCH AND DEVELOPMENT

G.M. Caton, U.S. Dept. of Energy, Oak Ridge National Lab., *P.O. Box X, Oak Ridge Operations Office, Oak Ridge, Tennessee* 37830 (W-7405-ENG-26)

A computerized inventory of current energy-related R&D projects that are conducted or sponsored in the United States will be maintained and updated. The inventory data base presently available consists of over 7000 entries. The scope of projects in the inventory is broad, including: (1) all types of energy sources -- fossil fuels, nuclear, hydroelectric, solar, geothermal, tidal, wind, wood, plant, animal materials, and waste products; (2) electric power -- generation, transmission, distribution, and storage; (3) energy uses and conservation -- heating and cooling, lighting, appliances, industrial processes, transportation, agriculture, etc.; (4) economic and legal aspects; and (5) environmental and health effects. This inventory will: (1) keep governmental agencies, universities, and private industry informed about the research others are conducting, thus preventing duplication of effort; (2) serve as a directory for research workers in similar areas; (3) indicate amount of research being conducted in various fields; and (4) give manpower information and expenditures spent in different areas of energy research. Associations, private companies, nonprofit laboratories, government agencies and universities are queried concerning any energy-related research that they are conducting or sponsoring. The resulting information is added to the data base. Various summary tables relate expenditures to type of research organization or sponsor, state where research is performed, subject area, research type - basic, applied, or development, etc. The inventory data base is also available for searching via the on-line ERDA/RECON computer system.

SUPPORTED BY U.S. Dept. of Energy, Div. of Biomedical & Environmental Research

1.0325,

SOLAR ENERGY APPLIED TO OPTIMUM DRYING OF FORAGES

B.L. Bledsoe, University of Tennessee, Knoxville Campus, Agriculture Experiment Station, Dept. of Agricultural Engineering, *W. Cumberland Ave. S.W., Knoxville, Tennessee* 37916 (7092-20190-004-A(2))

OBJECTIVE: Develop equipment and techniques for applying energy gathered by solar collectors to drying conventional and large packages of hay. Determine and evaluate equipment and techniques necessary for drying large packages of hay in the field without extensive use of solar collectors.

APPROACH: Both grass and legume forage will be harvested with conventional equipment. Different packages will be formed from this hay. Initially, conventional solar collectors will be used to supply the heat for drying these packages. Later, advanced designs will be used for large scale studies. Different equipment will be evaluated to apply supplemental energy, from solar sources, to individual hay packages in the field.

PROGRESS: A solar hay drying system consisting of two solar collectors, one of about 500 ft incorporated into the roof of a building and a free-standing collector of 1000 ft connected to drying chambers was constructred. This system can handle 2-one ton stacks of hay and 5 large round bales (about 1500 pounds each). Three separate tests were run late in the season. Each test consisted of 5 bales. Bale density ranged from 6-12 pounds per cubic foot. There was very little leakage of air around the bales. Maximum drying was from 35 percent to 17 percent in 10 days drying time. A piercer has been developed to pierce large round bales to assist natural ventilation. Tests show that the resiliency of the hay is such that a different principle must be used.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0326,

MACHINES FOR LOW-COST HAY MAKING ON SMALL FARMS

B.L. Bledsoe, University of Tennessee, Knoxville Campus, Agriculture Experiment Station, Dept. of Agricultural Engineering, *W. Cumberland Ave. S.W., Knoxville, Tennessee* 37916 (TEN00066)

OBJECTIVE: Compare three hay making systems applicable to small farms (less than 75 acres of hay) growing 'Midland' bermudagrass hay with respect to: machine efficiency and hay production cost, quality of hay produced, acceptance and utilization of hay by beef animals in winter feeding trials.

APPROACH: Function-time data for evaluating machine efficiency and hay production cost will be taken for three hay cuttings each year. Selected hay units produced will be instrumented for temperature records during the curing period. Dry matter loss will be determined from time-weight data taken for selected units. Core samples from the hay units will be utilized by Plant and Soil Science Department and Animal Husbandry-Veterinary Science Department to determine hay quality. Hay produced will be fed to beef animals in winter feeding trials by the Animal Husbandry-Veterinary Science Department to determine acceptance and utilization of the hay produced by the three different methods.

PROGRESS: An open-type chamber (6 ton capacity) for drying large hay packages using solar heated air was completed. Two collectors were compared: the 512 sq. ft. shed roof of the drying chamber, half of which was painted black; and a 300 sq. ft. free-standing plastic film collector. Greater air temperature increases were obtained from the free-standing collector. Duct valve design allows use of air from the roof collector, the free-standing collector, a shutter vented to ambient air, or any combination of the three. Large roll bales of grass hay (mean density 8 lb./cu. ft.) were dried from 36 to 28% moisture content in 6 days during late November with the system. Swath drying studies begun in 1975 and repeated in late September 1976 showed again that conditioned hay, partially dried in the swath and then either tedded or raked into windrows, had more rapid drying rates than mowed-conditioned-windrowed hay or unconditioned hay dried in the swath. Swathed hay must dry to about 45% before the tedder will produce fluffy windrows. Evaluation of 3 conductor-type, rapid-reading, hay moisture meters was completed. Keeping the sample density constant improved reading accuracy. Swath sample pressures of 8 to 97 psi were evaluated. No one was superior, but consistent density inproved accuracy. Chopped samples g (Text Truncated - Exceeds Capacity)

SUPPORTED BY Tennessee State Government

1.0327,

SOLAR HEATING AND COOLING DEMONSTRATION - LUBBOCK, TEXAS

G. Deering, (No Performing Organization Reported), Lubbock Texas, *Texas*

The project is a 4,050 square foot single family dwelling integrated with a solar heating and domestic hot water preheating system. The high wind velocities associated with the area dictated a low-profile building and collector area. The thermal mass of the house was increased by the use of thick masonry walls and floors. Additional energy conserving features include: improved insulation, reduced infiltration, supply air, and an overhang to block the summer sun. Also, glass area is minimized and windows are double glazed.

SOLAR APPLICATION: Heating and hot water. Collector: 312 square feet air-cooled flat-plate manufactured by Solaron.

STORAGE: 9.4 tons of rock 3/4 inches to 1 1/2 inches diameter within a triangular rock bin behind the collector. There are 60 pounds per square foot of collector.

DISTRIBUTION: Forced air. Air is blown through the rock storage by an air to air heat pump with a two-speed fan for circulation. The ductwork is installed in the ceiling with insulated air mains.

AUXILIARY ENERGY SYSTEM: Gas-fired furnace. The furnace provides supplemental heat as required. Cooling is achieved electrically.

DOMESTIC HOT WATER SYSTEM: 80 gallons of water are stored in a conventional hot water tank. Water is preheated by a heat exchanger in the ductwork.

COOLING: Natural ventilation. Heat pump is not solar assisted.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0328,

SOLAR HEATING AND COOLING DEMONSTRATION - SAN ANTONIO, TEXAS

Unknown, San Antonio Ranch Ltd., *San Antonio, Texas*

The project involves the integration of a solar heating and cooling system into three single family detached dwellings. The contemporarily-styled homes have floor areas of 2,044, 1,825, and 1,814 square feet. All are two stories in height and built without a basement. One dwelling makes use of prefabricated concrete wall panels with a site applied coating of stucco. Added wall, floor and ceiling insulation reduce the dwelling's heat losses. The solar collectors are incorporated on the houses sloping south-facing roofs.

SOLAR APPLICATION: HEATING AND COOLING COLLECTOR: 850 (approximately) square feet liquid-cooled flat-plate manufactured by Lennox per dwelling.

STORAGE: 1,000 gallons of water within a 5 feet 4 inches diameter storage tank buried in the ground.

DISTRIBUTION: Forced air. Heated water from storage passes through heat exchange coils in the primary supply duct. A fan in the ductwork circulates air through the coils, warming the air, which is distributed to the living spaces.

AUXILIARY ENERGY SYSTEM: Gas-fired boiler. The boiler provides hot water to the heating coils when storage temperatures cannot satisfy the dwelling's total heating demand.

DOMESTIC HOT WATER SYSTEM: Conventional system.

COOLING: An Arkla Absorption cooling unit. Uses hot water from solar storage to develop cold water which is pumped through coils in the primary supply duct.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0329,

USE OF SOLAR ENERGY FOR MECHANICAL DRYING OF PEANUTS IN THE SOUTHWEST

N.K. Person, Texas A & M University, College Station Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *College Station, Texas* 77843 (7093-20190-005-A)

OBJECTIVE: Develop equipment and procedures for using a solar powered, modified heat pump to dry and cure peanuts.

APPROACH: The operating principles of refrigeration systems in a closed-air system will be determined and the influence of such factors as airflow rate, initial moisture content of the peanuts and product temperature on refrigeration requirements will be measured. Based on these findings a closed-air system, in which the air leaving the drying peanuts will pass over the evaporator to remove moisture, then to the condenser unit to be heated before being moved back to the peanuts, will be constructed and tested. The modified heat pump in closed-air system will be powered by energy from a solar collector.

PROGRESS: A closed-air drying system using a refrigeration compressor with a nominal rating of 1 1/2 tons connected with a 4 ft. 4 ft. x 8 ft. plywood bin was used to dry 1-ton loads of peanuts. These peanuts had an average incoming moisture content of 24 percent and were dried to below 10 percent in an average time of less than 40 hours. The average energy efficiency ratio (ERR) was 10.7 BTUH per watt input. The coefficient of performance (COP) was 3.1. Analyses of the peanuts dried with this system showed that the grade factors were not significantly different than those dried in conventional driers.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0330,

PREDICTION AND CONTROL OF WATER USE EFFICIENCY IN CROP PRODUCTION

C.H. VanBavel, Texas A & M University, College Station Campus, Agricultural Experiment Station, Dept. of Soil & Crop Science, *College Station, Texas* 77843 (TEX01754)

OBJECTIVE: Devise and experimentally test simulation models of crop canopies that can give prediction of their water use efficiency, defined as the ratio between the carbon and water exchange between the crop and its environment. To employ acceptable models for the prediction of water use efficiency of crop production in a wide spectrum of environmental conditions.

APPROACH: Simulation models will be formulated from available analytical and numerical relations between carbon assimilation and water loss on the one hand, and environmental parameters on the other. The value of such models will be first examined under idealized conditions in a laboratory simulator of the outdoor environment. Next, field experiments will be arranged in which short term simultaneous measurement of CO(2) and H(2)O exchange by the crop will be made in addition to the variables that make up the environment and as needed in the model calculation. Experimental data will be automatically recorded in computer-compatible form. A mobile laboratory for field studies of water use efficiency will be assembled.

PROGRESS: Evaporation control in the dry-land areas of Texas is continuing need. As a follow-up on the theoretical analysis of the water conserving effect of water repellent mulch, a small field test was designed at the Lubbock research station. A centimeter thick mulch was prepared using natural soil clods and a commercial water repellant. Another plot was covered with gravel. As of September 1976, a weekly balance of water storage and losses is maintained and, using local weather data, these quantities are also calculated. Final results will be obtained in the early summer of 1977. An analysis of the role of declining soil water content in the decrease of transpiration by crops showed that under the usual range of root densities and soil properties, the ability of soil to conduct water is not a critical item - allowing models of crop water and efficiency to be simplified. A study was made of the water use efficiency of crops growing in a solargreenhouse in which the roof absorbs unneeded heat during the day and releases same at night. Water use is reduced by about two thirds whereas calculated productivity is reduced by only one fourth. A controlled environment study of the water extraction pattern by soybeans during a dry period was started and continues at this time. Observed distribution of water content in the root-zone will be compared with calculated values.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Texas

1.0331,

CONTROL OF PLANT ENVIRONMENT IN FLUID-ROOF SOLAR GREENHOUSE

C.H. VanBavel, Texas A & M University, College Station Campus, Agricultural Experiment Station, Dept. of Soil & Crop Sciences, *College Station, Texas* 77843 (7009-20690-022-A)

OBJECTIVE: Determine the feasibility of using thin film of selected fluids in the roof of a greenhouse to selectively absorb and store for later use, solar radiation not useful in photosynthesis by greenhouse plants.

APPROACH: Construct a dynamic simulation computer model that describes the energy disposition in a solar greenhouse with a fluid roof that is selectively transparent for photosynthetically active radiation. Evaluate the potential energy savings and other advantages of such a solar-heated, fluid-roof greenhouse. Add fluid circulation and storage to an existing greenhouse (23 m floor area) and install instrumentation to provide data for testing adequacy of model as well as comparison of effectiveness of various selective fluids.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0332,

SOLAR HEAT STORAGE SYSTEMS FOR RICE DRYING

P.E. Jenkins, Texas A & M University, College Station Campus, School of Engineering, Dept. of Mech Engin, *P.O. Box F E 44, College Station, Texas* 77843 (7090-15701-003-G)

OBJECTIVE: Determine optimum method of storing solar heat to be used as supplemental heat for rice drying after sunset.

APPROACH: Develop a model to simulate solar collection and heat storage systems for optimization studies. Both water storage and pebble rock storage systems will be included and design a solar heat storage system for experimental deep-bed rice dryers, 9 feet in diameter with nominal capacity for 194 cwt. of rice airflow rate of 1200 cfm (6.2 cfm/cwt) to provide a 10 F air temperature rice for a period of at least 16 hours.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Oklahoma - Texas Area

1.0333,

HEAT TRANSPORT IN GROUNDWATER SYSTEMS

D.L. Reddell, Texas A & M University, College Station Campus, Texas Water Resources Inst., Dept. of Agricultural Engineering, *College Station, Texas* 77843

Low grade heat from geothermal sources is presently available in many aquifers. In addition, a system has been proposed in which large quantities of groundwater are heated by solar heaters and the hot water injected into aquifers for long-term storage. The hot water would be pumped back to the surface for space heating during cold weather. Quantities of hot water in the form of waste heat is also available for storage underground in some areas.

Several hydrological and environmental problems exist for systems in which hot water is either injected or reclaimed from groundwater aquifers. This project will develop tools and procedures whereby the economic and environmental feasibility of such a hot water injection system could be evaluated at any location. Objectives of this research are: (1) Develop a computer simulation of the simultaneous movement of mass and energy (heat) in a groundwater aquifer with fluid density and viscosity variations, (2) Verify the numerical model with laboratory and field hot water injection systems, and (3) Evaluate the feasibility of storing hot water in groundwater aquifers.

SUPPORTED BY U.S. Dept. of the Interior, Office of Water Research & Technology

1.0334,

EXCITED STATES AND PHOTOBIOLOGY OF BIOLOGICAL MOLECULES

P.S. Song, Texas Tech University, School of Arts & Sciences, Dept. of Chemistry, *P.O. Box 4340, Lubbock, Texas* 79409

The photosynthetic light-harvesting pigment, peridinin-inchl-protein complex, was isolated from marine dinoflagellates including Glenodinium sp. The peridinin chl a ratio is 4:1. The energy absorbed by peridinin is transferred to the chl a molecule with 100% efficiency. Fluorescence lifetime data indicate that the energy transfer is much faster than fluorescence emission from chl a. The four peridinin molecules appear to form two allowed exciton bands which split the main absorption band into two circular dichroic components with opposite sign. The fluorescence polarization of chl a in the complex at 200 K is about 0.1 in both CD excitation bands of peridinin. From these data, a possible molecular arrangement of the four peridinin and chl molecules has been deduced for the complex. The structure of the complex deduced is also consistent with the observed exciton splitting of about 3,000 cm-1 at the intermolecular distance in the dimer pair of peridinin (about 12 A). This structural feature accounts for the efficient light-harvesting process of dinoflagellate as the exciton interaction lengthens the lifetime of peridinin (radiative) and the complex topology increases the energy transfer probability. The complex is, therefore, a useful molecular model for elucidating the mechanism and efficiency of solar energy conversion in vivo as well as in vitro.

SUPPORTED BY Robert A. Welch Foundation

1.0335,

FEASIBILITY STUDY FOR USE OF SOLAR ENERGY FOR FEEDLOT FEED MILL OPERATION

J.H. Strickland, Texas Tech University, School of Engineering, Dept. of Mech Engin, *P.O. Box 4340, Lubbock, Texas* 79409 (3090-12011-001-A)

OBJECTIVE: Determine the feasibility of providing a significant portion of the total energy requirements of a large feedlot feedmill by use of solar energy. Both the technical and economic aspects of several system designs are to be studied.

APPROACH: A systems analysis computer model is to be developed which will predict the performance of various solar to electric and solar to steam generating systems with various combinations of storage and auxiliary power. Information concerning daily feedmill energy demand is to be obtained experimentally from a typical feedmill and incorporated into the systems model. Sizing of various system components will be optimized with respect to life cycle economic considerations.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Illinois - Indiana - Ohio Area

1.0336,

EVALUATION OF TECHNIQUES FOR DRYING AND STORING RICE TO MINIMIZE FUEL REQUIREMENTS

D.L. Calderwood, U.S. Dept. of Agriculture, Agricultural Research Service, Rice Res, *Rte. 5 Box 784, Beaumont, Texas* 77704 (7303-20590-001)

OBJECTIVE: Develop rice drying and storage procedures and equipment that minimize energy requirements while maintaining market quality.

APPROACH: Test drying procedures in laboratory and pilot plant investigations to determine combinations of heated-air temperatures and throughput rates that minimize gas and/or electrical consumption. Test solar heat collectors to supply heat for rice drying by direct application and by recharging desiccants. Determine the effect of additional field drying of selected rice varieties on yield, milling quality and grade by harvesting plots periodically during a 30-day interval as moisture content drops from 24 to 14 percent.

PROGRESS: Solar heat aided deep-bed rice drying in tests run during the 1976 harvest season by reducing both drying time and electrical energy consumption by about 30% compared with unheated air-drying. A small reduction in milling yield was noted in samples from dryers using solar heat compared with unheated air-dried samples. The use of a stirring auger did not change the amount of milling yield reduction, but by operating the stirring auger 9 hours each day, there was no great difference in the moisture contents of rice samples taken from the top, center and bottom of dryers. Tests on reducing energy for drying by delaying harvesting were continued with long-grain varieties, Lebonnet and Labelle,

and medium-grain varieties, Brazos and Nato, used in 1976 tests. While much less drying was needed for rice that remained unharvested for 30 days after the first samples were harvested, the yield per acre and milling yield dropped significantly when harvesting was delayed more than 10 days. The combination of continuous-flow, heated air-drying for high moisture rice and in-bin drying to dry rice from 16 to 12.5% moisture content resulted in using less LP gas but more electrical energy than was required to do all the drying in a continuous-flow, heated air-dryer.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Oklahoma - Texas Area

1.0337,

SOLAR ENERGY COLLECTION FOR POWER AND HEAT GENERATION

A.F. Hildebrandt, University of Houston, School of Arts & Sciences, Dept. of Physics, *3801 Cullen Blvd., Houston, Texas* 77004 (3090-12012-002-A)

OBJECTIVE: Develop Solar collector design information to model a solar power system suitable for operation of a cattle feedlot and for irrigation pumping.

APPROACH: Using information and data developed in previous solar energy collector studies and observed solaration data, designs employing several types of solar collectors will be modeled and energy production under specific conditions will be described. This will then be combined with solaration data to predict peak, average, and total power output capability for each type of collector systems. Cost factors for each solar energy collector system design will be described.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Illinois - Indiana - Ohio Area

1.0338,

SOLAR REGENERATED AIR CONDITIONING SYSTEM

Unknown, University of Texas, Austin Campus, School of Engineering, Dept. of Mech Engin, *200 W. 21st, Austin, Texas* 78712 (H-2313)

OBJECTIVES: Optimization of solar regenerated solid desicant air conditioning system for single multiple family dwellings. To select a solid desicant humidifier-evaporate cooler air conditioning system, study its dynamic responses and adapt the system for single or multiple family dwellings. $

SUPPORTED BY U.S. Dept. of Housing & Urban Development

1.0339,

SOLAR HEATING & COOLING DEMONSTRATION - DALLAS, TEXAS

Unknown, W. Brown Builders, *Dallas, Texas*

The project applies solar energy for space heating and domestic hot water to two single family detached dwellings. The first home is a 3,395 square foot brick and cedar-sided ranch house. To conserve energy window areas facing north, west and east are reduced and the roof overhang is designed to shade large south-facing windows in the summer and admit the heat of sunlight in winter. The second bricked, wood frame residence has 2,300 square feet of living space. Both dwellings have the solar collectors mounted at the optimum tilt on the sloping south-facing roof.

SOLAR APPLICATION: HEATING AND HOT WATER COLLECTOR: 504 square feet (first house) and 417 square feet (second house) liquid-cooled flat-plate manufactured by Sunsource.

STORAGE: 2,000 gallons of water within an insulated storage tank located in the basement. A heat exchanger transfers energy from the collector to a sump tank which is then transferred to the central storage tank.

DISTRIBUTION: Forced air. Hot water from storage passes through some heat exchanger coils in the supply air ductwork. A fan circulates air past the coils through the house via the ducts.

AUXILIARY ENERGY SYSTEM: Gas-fired furnace. The furnace located within the primary supply duct provides supplemental heating as required.

DOMESTIC HOT WATER SYSTEM: 120 gallons of water within an insulated tank is preheated as water from storage is pumped to the distribution fan unit. The preheated water passes through a conventional heater before distribution.

COOLING: Conventional gas fired air conditioner and natural ventilation.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0340,

SOLAR HEATING & COOLING DEMONSTRATION - SALT LAKE CITY, UTAH

Unknown, Terracor Utah, *Salt Lake City, Utah*

The project involves the application of a solar heating system to 3,000 square foot single family dwelling. The three-story split-level house integrates the solar system within the building. A number of energy conserving features are incorporated in the design to reduce the dwelling heat loss. These include a skylit airlock entry, double-glazed windows where the outer pane is insulated and the inner pane reflective and 2' x 6' studs spaced 24' on center to allow for thicker wall insulation.

SOLAR APPLICATION: HEATING COLLECTOR: 585 square feet air-cooled flat-plate manufactured by Solaron Corporation.

STORAGE: 16 tons (295 cubic feet) of 1 1/2' diameter rock within an insulated storage bin located in the basement.

DISTRIBUTION: Forced air. An air handling unit transports heated air from the collector to the rock storage bin. Warmed air is removed from rock storage by a fan and distributed throughout the house by ducts.

AUXILIARY ENERGY SYSTEM: Gas-fired furnace. The furnace is located on-line between rock storage and occupied spaces, apply total or partial heating as required.

DOMESTIC HOT WATER SYSTEM: Conventional system.

COOLING: Natural ventilation.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0341,

SOLAR HEATING AND COOLING DEMONSTRATION - BROOKLINE, VERMONT

Unknown, Grassy Brook Village Government, *Brookline, Vermont*

The project consists of ten three-bedroom, 1,200 square foot living units clustered around a common courtyard to form a 12,000 square foot modular complex. The complex makes use of a shared central solar collection and storage system. The collectors and storage elements are located apart from the buildings. Energy conservation features include: common walls reducing by 18 percent vertical exterior wall area exposed to outside, double-glazed windows, extra insulation, and sodded roof.

SOLAR APPLICATION: HEATING AND HOT WATER COLLECTOR: 2,520 square feet liquid-cooled, flat-plate arranged in an array of three rows, two panels high each in a sawtooth fashion.

STORAGE: Three 5,000 gallon steel tanks store 15,000 gallons of water to be heated by heat exchange coils from the collectors.

DISTRIBUTION: Forced air. Six fan-coil units per dwelling distribute heat air from the central heating system. A ten-ton electric heat pump is connected to a separate 5,000 gallon tank receiving low-grade heat from the collectors.

AUXILIARY ENERGY SYSTEM: An oil-fired boiler has the capacity to provide 100 percent of required heating. Wood stoves in each dwelling provide back-up.

DOMESTIC HOT WATER SYSTEM: A preheat coil from the collectors heats 600 gallons of water stored in a separate domestic hot water storage tank.

COOLING: Natural ventilation.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0342,

SOLAR HEATING AND COOLING DEMONSTRATION - BERRYVILLE, VIRGINIA

Unknown, Ritters Buildings, *Berryville, Virginia* 22611

The project involves the application of a solar heating, cooling and domestic hot water preheating system to a single family detached dwelling. The two-story house has 1,664 square feet of heated/cooled floor area. The design is compact and well-insulated. Roof-mounted collectors on the garage heat thermal storage located in the basement.

SOLAR APPLICATION: HEATING, COOLING AND HOT WATER COLLECTOR: 210 square foot liquid-cooled flat-plate manufactured by Sunworks.

STORAGE: 1,250 gallons of water within concrete storage tank coated with polyester and epoxy located in the basement.

DISTRIBUTION: Forced air. Hot water from storage passes through heat pump arranged in-line with the distribution ducts. Air is blown over copper coils, heated and distributed to the occupied spaces.

AUXILIARY ENERGY SYSTEM: Electrical resistance, heat pump. 14.4 KW strip heater located in the primary supply duct along with the heat pump provides supplemental energy as required.

DOMESTIC HOT WATER SYSTEM: A copper coil in storage preheats the domestic hot water supply prior to entering a conventional 60 gallon electric water heater.

COOLING: Solar assisted heat pump. Main thermal storage receives heat removed during daytime by the heat pump to be disposed of to the cooling tower at night.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0343,

SOLAR HEATING AND COOLING DEMONSTRATION - ALEXANDRIA, VIRGINIA

Unknown, Rust Construction Co. Inc., *210 Payne St., Alexandria, Virginia* 22314

The project combines a solar heating and domestic hot water preheating system with a two-story 2,115 square foot single family residence. Roof-mounted collectors are connected with a water storage tank located in the basement. A skylight in the center of the south-facing roof supplies light as well as heat to the dwelling's interior spaces.

SOLAR APPLICATION: HEATING AND HOT WATER COLLECTOR: 459 square foot liquid-cooled flate-plate manufactured by Solar Corp. Above the selective coating on an aluminum absorber are two glass cover plates.

STORAGE: 1,000 gallons of water within an insulated 4 feet diameter by 11 feet long storage tank located in the basement.

DISTRIBUTION: Forced air. Hot water from storage is circulated through coils in the primary supply ducts. A fan distributes the air warmed by the coils to the living spaces by ducts.

AUXILIARY ENERGY SYSTEM: Electrical resistance, heat pump. Electric resistance coils in the supply ducts plus a heat pump provide total or partial energy source to the solar heating system.

DOMESTIC HOT WATER SYSTEM: Hot water storage circulates through heat exchanger within a conventional water heater preheated the domestic hot water supply.

COOLING: Heat pump, but not solar assisted. Natural ventilation.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0344,

SOLAR HEATING AND COOLING DEMONSTRATION - VIRGINIA BEACH, VIRGINIA

Unknown, Sir Galahad Co., *Virginia Beach, Virginia*

The project consists of two-story single family detached dwelling integrated with a solar heating and domestic hot water preheating systems. The roof-mounted collectors and a basement storage tank provide solar heat to the 1,896 square foot home. The contemporary wood frame home uses brick, cedar shingles, and wood siding for the exterior. Added floor, wall and ceiling insulation reduces infiltration and decreases heat loss.

SOLAR APPLICATION: HEATING AND HOT WATER COLLECTOR: 624 square feet liquid-cooled flat-plate manufactured by Revere. A copper absorber is located below two glass cover sheets.

STORAGE: 1,250 gallons of water within an insulated welded rectangular steel tank located in the basement. Water is circulated through the collectors, heated, and stored in the tank. No heat exchanger is used.

DISTRIBUTION: Forced air. Heated water from the storage tank is pumped through copper coils in the ductwork. Air is blown over the coils, heated and distributed by ducts to the living spaces.

AUXILIARY ENERGY SYSTEM: Electric heating elements located in the primary supply duct provide total or supplemental heat as required.

DOMESTIC HOT WATER SYSTEM: Domestic hot water is preheated as it passes through the central

storage tank. The preheated water is stored in the tank of a conventional water heater.
COOLING: Natural ventilation.
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0345,
THE ENERGY CONSERVATION FACILITY
R.L. Goble, U.S. National Aeronautics & Space Admin., Office of Aeronautics & Space Technology, Langley Research Center, *Hampton, Virginia* 23665
DESCRIPTION: The objective of this effort is to demonstrate the application of NASA aerospace technology and industrial technology to advance the building industry in residential construction. Two of the major considerations are to utilize alternate energy sources which will eliminate or reduce the need for fossil fuel generated energy and to utilize water management systems to reduce water consumption. Other aerospace generated technology will be utilized that provides an advantage over existing materials, systems, or construction techniques. A single family residence will be constructed at Langley using ideas and innovations that will be commercially available in approximately 5 years. The best modern practices in construction, electrical, plumbing, and materials will be used, incorporating modular flexibility where possible. The initial approach will be to evaluate related ongoing work efforts and equipment availability on solar energy and wind energy collectors and converters, water and waste treatment systems and advanced systems for heating, cooling, water heating, lighting and other systems for a single family residence. Systems, materials for construction, and construction techniques will be chosen based upon using the most energy efficient system that is available incorporating the latest current technology and using some custom-made components and materials. All of the other NASA Centers will be asked to participate and provide candidate items and ideas to be included in the house.
ADDENDA: Estimated calendar year funding reported as 1975 $160,000.
SUPPORTED BY U.S. National Aeronautics & Space Admin., Office of Aeronautics & Space Technology, Langley Research Center

1.0346,
SOLAR/WIND ENERGY TO COOL TOBACCO STORAGE WAREHOUSES TO PROVIDE INSECT CONTROL
F.A. Iachetta, University of Virginia, School of Engineering & Applied Science, Dept. of Mech Engin, *Garrett Hall, Charlottesville, Virginia* 22903 (7093-20620-004-A)
OBJECTIVE: Determine energy requirements for cooling and maintaining tobacco storages at 4 C during winter months and examine solar energy alternatives for powering either vapor compression or absorption refrigeration units to provide thermal conditioning and wind energy driven fans for air cooling and circulation.
APPROACH: Tobacco stored in representative sheet metal warehouse in central North Carolina will be monitored for rate of heat transfer. Heat emission from warehouse walls and roof will be measured, and methods selected to economically reduce this type of radiation. Size and cost of solar and/or wind powered cooling systems having capacity to chill warehouse air to cool tobacco packed in hogsheads be 4 C or lower for 12 consecutive weeks during winter months will be determined.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Mid Atlantic Area

1.0347,
WASTE SYSTEMS AS SOLAR ENERGY RESERVOIRS
D.H. Vaughan, Virginia Polytechnic Inst. & State University, School of Agricultural & Life Sciences, Dept. of Agricultural Engineering, *Blacksburg, Virginia* 24061 (7093-20400-004A(2))
OBJECTIVE: Evaluate waste treatment systems such as lagoons as solar energy storage reservoirs, evaluate types of solar collectors for heating lagoons, and develop and evaluate methods for recovery of heat from waste systems through use of heat pumps.
APPROACH: Solar collectors for heating fluids such as found in waste treatment lagoons will be designed, and used to heat an existing lagoon. Heat pump systems for recovery of energy stored in the lagoon will be designed and used for space heating of a livestock shelter. Overall performance of the system will be evaluated by comparing performance with and without the solar energy input.
PROGRESS: An experimental solar heated swine nursery building has been installed and tested. The small nursery building (8' x 16' with 8' ceiling) is heated with a solar assisted heat pump. Heated water circulates through the inlet coils after being warmed by flat plate solar collectors (67 ft) and/or a heat exchanger submerged in an adjacent waste treatment lagoon. Use of an open pond such as the lagoon being used here is unsatisfactory for heat storage due to the large thermal capacity and heat losses. The lagoon does, however, provide a low-level backup heat supply during certain periods of operation. Because large open ponds cannot be maintained at warm temperatures during the winter and because the COP of the heat pump is best with warm inlet water temperatures, studies have begun on the effects of pond insulation and coverings on heat storage capability at 50-70 F water temperatures. Four small water impoundments have been constructed and are being instrumented. Data has been collected during the past year to evaluate system operation. (No pigs are housed in the facility at the present time). At very cold winter temperatures (0-20 F), the heat pump must operate outside its designed range (40-90 F). When the outlet water temperature from the heat pump drops below 35 F, the heat pump is set to shut off operation (low pressure cutoff). Heat pump manufacturers are being contacted to try to overcome problem.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Alabama - North Mississippi Area

1.0348,
WASTE SYSTEMS AS SOLAR ENERGY RESERVOIRS
D.H. Vaughan, Virginia Polytechnic Inst. & State University, School of Agricultural & Life Sciences, Dept. of Agricultural Engineering, *Blacksburg, Virginia* 24061 (VA-0333903)
OBJECTIVE: Evaluate waste treatment systems such as lagoons as solar energy storage reservoirs, evaluate types of solar collectors for heating lagoons, and develop and evaluate methods for recovery of heat from waste systems through use of heat pumps.
APPROACH: Solar collectors for heating fluids such as found in waste treatment lagoons, will be designed, and used to heat an existing lagoon. Heat pump systems for recovery of energy stored in the lagoon will be designed and used for space heating of a livestock shelter. Overall performance of the system will be evaluated by comparing performance with and without the solar energy input.
SUPPORTED BY Virginia State Government

1.0349,
SOLAR HEATING AND COOLING DEMONSTRATION - VIENNA, VIRGINIA
Unknown, Yeonas Co., *226 Maple Ave. W., Vienna, Virginia* 22180
The project outfits one new, single family detached dwelling with solar domestic hot water systems. The solar collectors are mounted on separate structural frame attached to the house's sloping south-facing roof. The frame tilts the collector for year round optimum solar radiation collection.
SOLAR APPLICATION: HOT WATER COLLECTOR: 21 square feet liquid-cooled flat-plate manufactured by Sunworks.
STORAGE: 65 gallon tank of a conventional water heater stores preheated water from the collector.
DISTRIBUTION: A copper coil within the storage tank preheats the domestic hot water supply as heated water from the collector circulates through the coil.
AUXILIARY ENERGY SYSTEM: Electric water heater. A conventional water heater with an auxiliary 4.5 KW electric heating element in the tank supplements the preheating system.
DOMESTIC HOT WATER SYSTEM: See collector, storage, distribution, and auxiliary for details.
COOLING: Not applicable.
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0350,
PROOF OF CONCEPT OF TWO NOVEL SOLAR HEATED GREENHOUSES
D.E. Straub, Ecotope Group, *747 16th Ave. E., Seattle, Washington* 98112 (7095-20691-014-A)
OBJECTIVE: Design, demonstrate and evaluate the concept of low-cost passive solar heating of greenhouses for use in area of limited space or water utilizing passively controlled ventilation/cooling systems and integrated plant and aquaculture production.
APPROACH: Construct and test a 'parabolic' greenhouse with a floor area of 360 ft , reflective and insulated parabolic north wall, a 5000 gal pond of water for solar energy storage and a growth area for fish (tilapia), and a thermal ventilation stack 20 ft high. Monitor the environmental and biological systems and compare theoretical and actual performance to specify equations describing transient behavior of the greenhouses. Use performance data to improve and optimize designs for passively heated and cooled greenhouses and maximizing greenhouse production.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0351,
SOLAR ENERGY CONVERSION IN MODELS OF THE PHOTOSYNTHETIC MEMBRANE
R. Cellarius, Evergreen State College, Graduate School, *Olympia, Washington* 98505
The photosynthetic process displays a high degree of efficiency in converting solar radiation into stored chemical potential. It is proposed herein to study photosynthesis as a solar energy conversion phenomenon by constructing models which mimic in detail the light absorption, excitation energy transfer, energy conversion (trapping), and charge separation processes of photosynthetic organisms. This research will involve an examination of photosynthetic membranes through constructive model building, using the components present in photosynthetic tissues as well as their chemical and physical homologs. Particular emphasis will be placed on constructing membrane and solid state models of various photosynthetic functions with a goal of both providing a better understanding of the structure-function relationship between plant tissues and photosynthetic energy conversion and eventually producing an efficient and stable solar energy transducer.
SUPPORTED BY U.S. National Science Foundation, Div. of Physiology Cellular & Molecular Biology

1.0352,
DIRECT PASTEURIZATION OF FRUIT JUICES USING SOLAR ENERGY
D.B. Davis, Washington State University, Graduate School, *Pullman, Washington* 99163 (7003-20510-019-A)
OBJECTIVE: Determine technical feasibility of using solar energy for direct pasteurization of fruit juices. Develop recommendations for designs of solar collectors suitable for fruit juice pasturization and determine effects of direct solar radiation exposure on product.
APPROACH: Survey commercial and experimental solar collector designs and select most feasible for direct food product pasteurization. Analyse available solar energy in Washington fruit processing regions and relate to energy needs for pasteurization. Measure minimum time-temperature parameters for safe pasteurization of fruit juices. Measure absortivities of different light wave lengths and test relative effects upon fruit juice sterilization and product quality (including color, nutrients and flavor).
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Florida - Antilles Area

1.0353,
UTILIZATION OF SOLAR ENERGY IN FOOD PROCESSING
D.C. Davis, Washington State University, School of Agriculture, Dept. of Agricultural Engineering, *Pullman, Washington* 99163 (WNP00403)
OBJECTIVE: Characterize energy use of specific unit processes that are important to the food processing industry of Washington State. Characterize solar energy availability at representative locations that are important centers for food processing in the state. Determine the potential for solar energy use at specific processing sites and necessary energy storage

capacities. Adapt existing processes or develop new processes that can efficiently utilize solar energy for food processing.

APPROACH: Published literature, personal communication, and field data collection will be used to obtain data for objectives 1 and 2. Processing operations and solar radiation characteristics will be studied together to define appropriate solar collection and storage systems. Technical and economic factors will be evaluated for solar energy systems. Where process modifications are needed to utilize solar energy efficiently, investigations into new or improved processes will be conducted. Equipment will be constructed and tested to evaluate these processes.

PROGRESS: Activity has focused primarily on objectives 1 and 2. Defining energy requirements of food processing operations and locating sources of solar energy data for the state. A review of literature on applications of solar energy to food processing is in progress. Information on energy use in some major food processing operations in the state has been obtained. State and national weather data sources have been contacted to identify official sources of solar radiation records. Investigation into solar collector types and their suitability for use in food processing operations has been initiated. Correspondence with manufacturers has resulted in the identification of some collectors that may be suitable.

SUPPORTED BY Washington State Government

1.0354,

SOLAR-ASSISTED DRYING OF HOPS

G.A. Kranzler, Washington State University, School of Agriculture, Dept. of Agricultural Engineering, *Pullman, Washington* 99163 (7003-20190-015-A)

OBJECTIVE: Investigate by field study the technical and economic feasibility of utilizing solar energy as a supplemental thermal source for the drying of hops by means of: Preheating ambient system intake air and conditioning kiln exhaust air for system recirculation.

APPROACH: A portion of the roof of an existing conventional design multi-kiln hop drier plant will be modified to serve as a solar collector. The collector design will permit preheating outside air or conditioning and recirculating kiln exhaust air. Both modes of operation will be evauated and energy conserved will be determined by comparison with a second unmodified kiln.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

1.0355,

APPLICATION OF SOLAR ENERGY TO THE DRYING OF HOPS

G.A. Kranzler, Washington State University, School of Agriculture, Dept. of Agricultural Engineering, *Pullman, Washington* 99163 (WNP00428)

OBJECTIVE: Investigate by field study the technical and economic feasibility of utilizing solar energy as a supplemental thermal source for the drying of hops by means of: Preheating ambient system intake air and, conditioning exhaust air for system recirculation.

APPROACH: A conventional multi-floor hop kiln will be employed. The roof will be modified to permit solar preheating of ambient air or conditioning of recirculated exhaust air to supplement the drying system of a single kiln floor. Energy inputs to the solar assisted drying floor and to a conventionally operated control floor will be monitored and compared to assess technical and economic results.

SUPPORTED BY Washington State Government

1.0356,

SOLAR HEATING & COOLING DEMONSTRATION - SUMMIT, WISCONSIN

Unknown, Friedman Rosen & Zien, *Summit Lake, Wisconsin* 54485

The project is an application of solar energy to the space heating and domestic hot water needs of a single family detached dwelling. The living spaces total 1,398 square feet. The contemporary wood frame building is simply detailed and compact in shape. Roof-mounted collectors supply a basement storage tank. The project illustrates an innovative concept for the integration of a heat pump with a solar energy system.

SOLAR APPLICATION: HEATING AND HOT WATER

COLLECTOR: 858 square feet air-cooled flat-plate manufactured by Zien. The air collector passes the air over the black painted, galvanized steel absorber twice.

STORAGE: 40 tons of 1 1/2 inch diameter rocks located in the basement within a 'U' shaped rock bin with a heat pump in the center. Domestic hot water is stored in a 150 gallon preheat tank.

DISTRIBUTION: Forced air. The heat pump fan circulates air over heated rocks in storage. The warmed air enters ducts around the storage bin and is distributed to the occupied spaces.

AUXILIARY ENERGY SYSTEM: Two 4 kw electric heaters are built into the heat pump which is used to distribute solar heated air. A 6 kw heater is back-up in case of compressor failure.

DOMESTIC HOT WATER SYSTEM: A copper heat exchange coil in the ductwork of a separate 100 square foot one-pass air collector transfers heat from air to water for storage in the preheat tank.

COOLING: Solar storage assisted heat pump and natural ventilation.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0357,

SOLAR ENERGY UTILIZATION IN FOOD PROCESSING SYSTEMS

D.B. Lund, University of Wisconsin, Madison Campus, Agricultural Experiment Station, Dept. of Food Science, *116 Agricultural Hall, Madison, Wisconsin* 53706 (7093-20510-009-A)

OBJECTIVE: Establish energy demands of hot water and steam for three selected plants, incorporate models for solar energy supply and collection to determine capability of solar energy in food processing, analyze economic feasibility.

APPROACH: Water flow rates, temperatures and steam demand will be obtained from literature and direct measurements in cooperating plants. Models will be developed to simulate quantity and energy level of each stream. Models will then be used with the TRNSYS (1975) program (transient system stimulation developed by the Solar Energy Laboratory, U.W.-Madison on NSF and ERDA funding) to determine compatability of energy needs with supply and collection systems.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Florida - Antilles Area

1.0358,

UTILIZATION OF SOLAR ENERGY IN CHEESE PROCESSING OPERATIONS

D.B. Lund, University of Wisconsin, Madison Campus, Agricultural Experiment Station, Dept. of Food Sciences, *116 Agricultural Hall, Madison, Wisconsin* 53706 (7093-20530-003-A)

OBJECTIVE: Analyse energy reuse in cheese processing, determine feasibility of heat exchanger network for energy conservation, develop system changes to maximize solar energy augmentation in a cheese processing system.

APPROACH: Select plants to study based on product and process diversity and production capacity. Develop strategies for energy use and reuse within selected systems. For a selected cheese plant, design and develop an optimum heat exchanger network for maximum energy utilization. Develop solar collection systems to augment hot air or water using solar collection and storage system which is most attractive economically.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Florida - Antilles Area

1.0359,

IMPROVEMENTS IN DRYING TECHNOLOGY

W.T. Simpson, University of Wisconsin, Madison Campus, U.S. Dept. of Agriculture Forest Products Lab., *P.O. Box 5130, Madison, Wisconsin* 53706 (FPL-3214)

OBJECTIVE: Advance the level of technology of wood drying above the level available at present, and improve the performance and yield of wood products through improved drying practices.

APPROACH: Reduce the cost of drying hardwood lumber by optimizing and, where possible, integrating techniques such as high-temperature drying, segregation, pretreatments, kiln automation, and rapid, in-line drying of clear cuttings; and assess the effect of drying conditions on shrinkage and warp. Increase the level of control over the softwood drying process in order to reduce the variation in final moisture content after drying, and to quantify the effect of high-temperature drying on the strength of softwood dimension limber and develop minimum strength-reducing drying processes. Reduce the dependence on fossil fuels in wood drying processes by designing and building a solar lumber kiln and demonstrating its technical feasibility.

PROGRESS: Drying procedures were developed to reduce coloration that occurs in drying maple sapwood, and thus preserve the highly valued 'white' maple color. Results of research in several different techniques to accelerate oak lumber drying were combined into one drying system. Presurfacing, presteaming, schedule acceleration and smoothing, and high temperature (230 degrees F) drying were combined to dry 1-inch oak lumber in approximately 10 days compared to 21 days with conventional drying. Tests on the quality of the lumber dried this quickly will continue. Exploratory studies indicate that some hardwood species can be dried from the green condition at high temperatures with no defects, thus offering significant savings in energy and reductions in drying time. Lumber from American elm trees killed by Dutch elm disease was kiln dried successfully. Douglas-fir dimension lumber (2x4, 2x6) was dried at 230 degrees F under restraint with no defects. Spectrophotometry tests for spectral diffuse reflectance are showing some promise as a means of segregating bacterially infected lumber. A study has been initiated to determine the severity of the wetwood drying problem in young-growth western hemlock. A prototype solar dryer was built and tested as part of an AID sponsored project to design low-cost solar dryers for developing countries. As part of the operational test of the design, I-inch northern red oak was dried def (Text Truncated - Exceeds Capacity)

SUPPORTED BY U.S. Dept. of Agriculture, Forest Service, Forest Products Lab.

1.0360,

SOLAR HEATING AND COOLING DEMONSTRATION - MILWAUKEE, WISCONSIN

Unknown, University of Wisconsin, Milwaukee Campus, Graduate School, *Bolton Hall, Room 160, Milwaukee, Wisconsin* 53201

PROJECT SUMMARY: The project involves the rehabilitation of an existing single family dwelling and the adaptation of the dwelling design for solar heating and domestic water heating. The two story wood framed house has a floor area of 2,400 square feet. Numerous energy conserving techniques include: additional wall and roof insulation; rain water collection system connected to a cistern for use in water closet flushing; enlarged south-facing windows to increase solar heat gain during the water, combined with insulated shutters and panels to reduce heat loss and infiltration in the evenings or on sunless days; and the use of large overhangs to shield south-facing windows from summer solar heat gain.

SOLAR APPLICATION: Heating and hot water.

COLLECTOR: 600 square foot air-cooled flat-plate manufactured by Solaron Corporation with reflective radiation gain from roof and catwalk surfaces; south-facing windows. Domestic hot water is heated by a separate 55 square foot liquid-cooled flat-plate collector.

STORAGE: 22 tons of one to two inch diameter rocks within an 8' x 15' x 5' concrete block storage bin in the basement. The storage bin is insulated with three to five inch polyurethane applied to the exterior.

DISTRIBUTION: Forced air, two stage thermostat with manual damper repositioned for seasonal changeover; natural radiation and convection.

AUXILIARY ENERGY SYSTEM: Gas furnace, between storage and distribution ducts provides supplemental heating during periods of extreme cold or cloudiness.

DOMESTIC HOT WATER SYSTEM: 55 square foot liquid-cooled flat-plate collector (Grumman Sunstream) preheats domestic hot water by a heat exchanger in a tank in the attic before passing to a conventional water heater.

COOLING: Natural ventilation.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0361,

COLLECTION & REVIEW OF DATA ASSOCIATED WITH LONG-TERM ENERGY ASSESSMENT OF SOLAR HEATING, WIND ENERGY & FORESTRY BIOMASS ENERGY OPTIONS

Unknown, Middleton Associates, *Toronto, Ontario, Canada*

No summary has been provided to the Smithsonian Science Information Exchange.

SUPPORTED BY Dept. of Energy Mines & Resources

1.0362,

ZERO-ENERGY HOUSE

Unknown, Danmarks Tekniske Hojskole, Lab. for Heat Insulation, *Copenhagen, Denmark*

The idea of a highly insulated, solar-heated house with a high degree of heat recovery was expressed by professor V. KORSGAARD in May 1973, because of the very large part of Denmark's imported energy that goes to space heating in spite of the many years of work on the improvement of insulation standards here. Altered building style, lighter sheathing, greater desire for comfort and larger total built-up area have all far outpaced the effect of increased insulation in both existing dwellings and new housing. When the energy crisis erupted it became possible to realize the project.

AIM OF THE PROJECT: 1) to ascertain how long heat consumption can be reduced with heavy insulation, night insulation of windows, controlled low exchange of air, heat recovery from air exchange and hot water used; 2) to test a year-round solar heating system with flat-plate solar receiver and heat storage in heavily insulated water tanks; 3) to test the house's living quality with a family in residence.

SUPPORTED BY Government of Denmark

1.0363,

DRYING AND STORING OF RICE

A.A. Ibrahim, Gameat Al Iskandaria, *Alexandria, Egypt* (8005-20590-001)

OBJECTIVE: Determine characteristic drying rates and moisture equilibria for rice grown in Egypt; establish requirements for drying rice with natural air and with solar heat; develop indices for measuring rice deterioration.

APPROACH: Using standard techniques, measure the characteristic drying rate and equilibrium moisture content of rice fully exposed to air of selected temperatures and relative humidities. Measure direct and diffuse solar radiation and explore its application for drying rice. Develop deterioration indices based on temperature-moisture-time relationships and dry matter losses for use in evaluating in-storage drying procedures.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Kansas - Nebraska Area

1.0364,

CONSTRUCTION OF A SOLAR COLLECTOR PLANT FOR HEATING OF AN OUTDOOR SWIMMING POOL

F. Weil, Brown Boveri & Cie Ag, *Kallstadter Str. 1, 6800 Mannheim 1, Baden Wuertte, Federal Republic of Germany*

DESCRIPTION OF PROJECT: OBJECTIVE: Planning, design and construction of a solar collector for the heating of an outdoor swimming pool.

WORK PROGRAM: a) Construction of a 1100 absorber solar collector plant for life tests and demonstration purposes. b) Development of large scale manufacturing processes for solar heaters.

SUPPORTED BY Bundesministerium fur Forschung und Technische

1.0365,

10 KW SOLAR POWER PLANT

Gehrke, Dornier System GmbH, *Postfach 648, 7990 Friedrichshafen, Baden W., Federal Republic of Germany*

DESCRIPTION OF PROJECT: OBJECTIVE: Design and construction of a solar driven 10 kW turbogenerator for local TV-educational systems, irrigation pumps and other applications in developing countries.

WORK PROGRAM: a) System design and thermodynamic calculation. b) Design of the collector array and construction. c) Fixing of components and auxiliary units. d) Turbine design, construction, manufacture and test run. e) Generator design, construction, manufacture and test run. f) Turbogenerator integration and test. g) Electrical supply, plant control and regulation. h) Test assembly, performance and analysis.

ADDENDA: Subcontractor: KKK, Frannkenthal.

SUPPORTED BY Bundesministerium fur Forschung und Technische

1.0366,

HEAT STORAGE

Unknown, Electricite de France, *2 Rue Louis Marat, 75008 Paris, France*

Study the technical and economic aspects of devices for use in urban heating or for industry, heating greenhouses, and electricity production, etc. Apply this to the use of solar energy.

ADDENDA: Performing organization: Electricite de France.

SUPPORTED BY Electricite de France

1.0367,

A SEARCH FOR ALGAE STRAINS WITH HIGH PHOTOSYNTHETIC EFFICIENCY FOR SOLAR ENERGY CONVERSION

I. Ohad, Hebrew University of Jerusalem, Dept. of Biological Chemistry, *P.O. Box 499, Jerusalem, Israel*

As a result of our work on the biogenesis of chloroplast membranes, we have isolated mutant strains of unicellular algae able to grow relatively fast and perform photosynthesis quite efficiently. Our present program is devoted to devising an analytical system for the isolation and improvement of strains of algae able to utilize with efficiency high light intensity for growth of bio-mass while containing high level of protein and carbohydrate but low levels of chlorophyll.

SUPPORTED BY Hebrew University of Jerusalem

1.0368,

SOLAR COOLING OF GREENHOUSE

S.M. Moustafa, Kuwait Inst. for Scientific Research, *P.O. Box 24885, Safat, Kuwait*

OBJECTIVE: Design and construct prototypes of specially designed greenhouse utilization systems.

APPROACH: Passive greenhouse systems with controlled light and heat flow. Partially sunken and evaporative cooling is employed, excess heat is utilized in desalination.

PROGRESS: Two of six potential designs are completed and testing is underway.

Ecological parameters for terrestrial studies: Latitude, 29.4 degrees N; Soil types, sandy; Months of greatest moisture, November; Growing season, 8 months; Mean annual rainfall, 110 mm; Mean annual humidity, 40 percent.

SUPPORTED BY Kuwait Inst. for Scientific Research

1.0369,

PHOTOCATALYZED PRODUCTION OF FUELS BY MEANS OF SOLAR ENERGY

A. Mackor, Central Org. for Applied Scientific Research T N O, Inst. for Organic Chemistry, *Croesestraat 79, Utrecht, Netherlands*

The research concerns the hydrogeneration of simple molecules (e.g. CO_2 and N_2) photocatalysed by a photo-excited organo metal complex. The reducing agent is a hydrogen compound (e.g. water), decomposed by the excited simple molecule/organo metal complex.

SUPPORTED BY Central Org. for Applied Scientific Research T N O

1.0370,

DUCT WITH CHECK VALVE INTENDED MAINLY FOR VENTILATION USE

V. Andersson, (No Performing Organization Reported), *Sweden*

The demand for efficient airtight house construction today is high. As a result of this, negative pressure occurs only when the ventilation system used is mechanical exhaust air ventilation. Normally, the air is supplied to the house via inefficient joints or by vents placed below windows. Attics may be evacuated by natural ventilation, alternatively in combination with mechanical ventilation in order to remove heat and moisture.

The object of this project is to benefit from and put to good use the quantities of heat supplied to the attic both by transmission via the floors and by solar heating of the attic air. For this purpose a supply air device with check valve will be used. The valve is there to prevent backward draught when the ventilation fan is switched off.

In order to increase heat recovery further, the supply air system may be complemented by a heat exchanger.

SUPPORTED BY Styrelsen for Teknisk Utveckling

1.0371,

COOPERATION BY SWEDISH RESEARCHERS IN AMERICAN STUDIES OF THE TREATMENT OF WASTEWATER USING BIOLOGICAL PROCESSES

S. Delin, (No Performing Organization Reported), #64 Ostastigen Sodertalje, *Sweden*

OBJECTIVE: Studies of biological processes which utilize solar energy to build up high-molecular material from waste in aquatic environments will be carried out. Energy is extracted in the form of detoxification, pure water and protein, i.e. an entropy reduction is obtained.

APPROACH: Review and studies of international literature. Visits to and studies at companies involved in development work, in Tel Aviv and California, etc. Participation as guest researchers in Prof. Oswald's team at the University of California, Berkeley, USA.

PROGRESS: Research work is to concentrate on the basic parameters and development of individual steps in the process.

INTENDED USE OF RESULTS: In future stages experiments on series of steps in a Swedish project are planned.

SUPPORTED BY Namnden for Energiproduktionforskning

1.0372,

THERMOSIPHON BOILER

L. Horwitz, (No Performing Organization Reported), Apelvagen 25 S-18275 Stocksund, *Sweden*

Current research in the field of solar heat and solar energy for space heating and production of hot water is mainly concerned with conditions and solar collectors. The object of this project is to develop a new type of boiler for rational operation and storage of heat. Calculation of optimum storage sizes will be made so that good overall economy is obtained. The boiler will be developed both for detached houses and for industries and municipal installations. It will be capable of application in new production even in existing installations, and for space heating and/or water heating. As a consequence of the above object, a new system will be developed which, in connection with solar collectors, can give rise to considerable savings in energy consumption.

SUPPORTED BY Styrelsen for Teknisk Utveckling

1.0373,

FEASIBILITY STUDY OF THERMAL STORAGE IN A GREENHOUSE FOUNDATION

H. Larsson, (No Performing Organization Reported), *Sweden*

OBJECTIVE: To study the prospects of reducing greenhouse heating costs by storing surplus heat from solar radiation for a period of 1-14 days in a bin filled with gravel located in the foundation of the building and by utilizing this energy instead of oil for heating purposes during nights or cold days.

APPROACH: An existing construction (the so-called Naturhuset) at Saltsjobaden, in which the thermal storage of about 1000 KWh at 30 degrees C is in the foundation of the building, will be operated simultaneously with the greenhouse (about 100 m2), which is on the roof of the building, by installing fans and air ducts. The evaluation of the system will be carried out by means of recently acquired instrumentation for recording temperature, speed of the air-flow and moisture.

PROGRESS: The temperature of the thermal storage was raised by inputs of the warm greenhouse air, from 11 degrees C at the beginning of April to 22 degrees C at the end of May. Equalization of temprature was achieved by blowing about 2000 m3 of air/h through the greenhouse and thermal storage. Measurements show that this volume of air should at least be doubled to make better use of the storage capacity and energy-saving prospects of the system.

INTENDED USE OF RESULTS: The results of the measurements carried out in the spring and summer

of 1978 will provide basic dimensioning material for a full-scale test unit (600-1000 m2) to be built in the autumn-winter of 1978-79.
SUPPORTED BY Styrelsen for Teknisk Utveckling

1.0374,

MEASUREMENT OF COLLECTOR SYSTEM WITH REFLECTING WALL

J. Svensson, (No Performing Organization Reported), *Sweden*

OBJECTIVE: Adjustment of test unit. To measure the amount of energy which may be drawn out of a solar collector system with reflecting wall and used for house heating.

APPROACH: A half-scale unit consisting of a solar collector with reflecting wall has been constructed. A theoretical model has been made of this unit and the amount of heat it may supply. The aim of this project is to verify the model through measurements.

PROGRESS: A measurement station and suitable solar collector are available.

INTENDED USE OF RESULTS: The method concerned may be utilized for new production. Ostgotabyggen, a building enterprise which has shown its interest in this method, is considering applying primarily to single-family houses the experiences gained by this project.

SUPPORTED BY Styrelsen for Teknisk Utveckling

1.0375,

STORAGE OF HEAT IN ARTIFICIAL VOID ACCUMULATORS - FEASIBILITY STUDY

S. Andersson, Allmanna Ingenjorsbyran Ab, *Box 5511, S11485 Stockholm, Sweden*

The potential for storing heat in artificial void accumulators of 50 m3 to 50,000 m3. The accumulator may be constructed, for example, by excavation, thermal insulation, waterproofing and filling with gravel or macadam.

The project may be regarded as a special case of heat storage in aquifers, a project concerned with the use of very large accumulator volumes bounded by natural geological formations.

Certain fundamental studies and mathematical formulations, e.g., for heat propagation and heat loss, have been developed and will shortly be presented as the initial stage of the aquifer project.

Day storage and seasonal storage of heat is a basic condition for the utilization of solar energy. In this field the void accumulator can probably offer an economic and environmentally unobjectionable storage method suitable both for individual buildings and for larger groups of buildings.

SUPPORTED BY Statens Rad for Byggnadsforskning

1.0376,

ZERO ENERGY HOUSE WEST

H. Nordenstrom, Chalmers Tekniska Hogskola, Dept. of Architecture, *S40220 Goteborg 5, Sweden*

A grant has been awarded for preparation and coordination of the measurement programs which have formed the basis of measurements made in DTH's (Technical University of Denmark, Laboratory of Thermal Insulation) zero energy house and Termoroc's low energy house. The measurement principles to be used make it necessary to take an integrated view of 'the solar heating system measurement' including a preliminary as well as a renewed projection of the heating system and detailed analysis of the maintenance, operation and reliability of the components selected. The handling and evaluation of the collected data will be executed in a way to allow comparison between various experimental houses in accordance with the Swedish Council for Building Research (BFR) Document D1:1977 'Reporting format for solar energy building. Summaries of reports from three Swedish energy buildings' (In English), resulting in a final computer evaluation of the energy balance in the houses concerned.

Contacts have been established with Termoroc and ETH regarding the future work.

SUPPORTED BY Styrelsen for Teknisk Utveckling

1.0377,

SOLAR COLLECTORS OF TROUGHED SHEET-METAL

C. Nordstrom, Christers Arkitektkontor Nordstrom & Ab, *Alfhemsgatan 2, S41309 Goteborg, Sweden*

Detail development and testing of methods for: A) Making double use of the same troughed sheet-metal, partly as an absorbent and air duct system in a flat solar collector, partly as support and cover for roofs and for suspending insulation and ceilings. Building the solar collector into the carcass of the building in this way and using a new roof design will make it possible to reduce the cost for solar energy buildings to a considerable extent. B) The use of troughed cladding and roofing sheet-metal and standard manufactured fittings as main components in large, cheap solar collectors. The aim is to provide older (existing) buildings with solar collectors at a low extra cost in conjunction with external supplementary insulation.

The project includes testing and evaluating these methods in a pilot house in Askim (Gothenburg) and a detailed development of components and work methods in collaboration with institutions, authorities and firms. The project also aims at preparing for a rapid use of R and D results by means of a continuous design of alternative units.

SUPPORTED BY Statens Rad for Byggnadsforskning

1.0378,

MEASURING ENERGY CONSUMPTION IN A LOW-ENERGY HOUSE

E. Morawetz, Euroc Ab, *S20110 Malmo 1, Sweden*

The purpose is to study the technical-economic prerequisites for energy conservation in private dwelling houses through the use of solar energy, heat recovery from exhaust air and waste water, the reduction of heat losses through transmission and ventilation. This study will be carried out in an experimental house at Limhamn (Malmo) during the period October 1975 to September 1976. Extensive measurements will be carried out on the heating and climate conditioning system which has been installed. The energy consumption achieved will be calculated from the measurement data obtained and compared with the energy consumption measured for the house during normal operation.

A careful cost follow-up of the heating and climate conditioning system in the house covering development, material and installation costs will provide a possibility for comparing the energy cost savings made with the procurement cost for various types of system equipment.

If funds are granted, the project will be implemented in collaboration with I. Hoglund, Department of Building Technology, the Royal Institute of Technology.

SUPPORTED BY Statens Rad for Byggnadsforskning

1.0379,

INVESTIGATION OF AN INTERGRATED AQUATIC SYSTEM FOR STORING SOLAR ENERGY IN ORGANIC MATERIAL

C. Heden, Karolinska Institutet, Microbiological Engin Unit, *Solnavagen 1, S10401 Stockholm 60, Sweden*

OBJECTIVE: Investigation and evaluation of integrated bioconversion systems for solar energy utilization based on glycerol production by the green algae Dunaliella.

APPROACH: Laboratory investigations are being carried out to evaluate the microbiological and biotechnical conditions which influence glycerol production by Dunaliella and its recovery. In addition to the well-defined computer-coupled lab cultivations, preliminary 'scaled-up' outdoor cultivations will also be performed during the summer months. Various microbial processes for the further bioconversion of the crude algal mass are also being investigated. The process include single cell protein, nitrogen fixation, production of liquid and gaseous fuels and other chemicals. Technical, economic, energy analytic and environmental evaluations will be performed on the processes.

PROGRESS: During the first year of the project equipment for computer-coupled photosynthetic cultivations has been designed and constructed. In addition, crude cultivations have been carried out with volumes up to 30 liters with good results. Preliminary experiments on glycerol bioconversion have been performed in the areas of SCP production, nitrogen fixation and solvent production with some encouraging results.

INTENDED USE OF RESULTS: Initially, the results of this work might have most impact in sunny equatorial regions, where such systems utilizing 'appropriate technology' could make contributions to local self-sufficiency. A well developed system, using perhaps higher levels of technology, could eventually make effective contributions in more northerly regions such as Sweden by allowing the exploitation of excess summertime solar influx and possibly storing it for wintertime usage.

SUPPORTED BY Namnden for Energiproduktionforskning

1.0380,

PILOT HOUSE FOR PRACTICAL TESTING OF ENERGY CONSERVING HEAT SYSTEMS

H. Brosenius, Kungliga Tekniske Hogskolan, Building Technology, *S10044 Stockholm 70, Sweden*

This project aims at applying and testing a number of arrangements developed by Professor H. Brosenius on a laboratory scale for low-energy heating of one-family houses. These will be applied and tested in an inhabited one-family building and the project will be carried out in collaboration between the applicant and the project leader. These arrangements all aim at providing flexibility in the heating system, i.e. the use of various energy forms without giving rise to investment expenses. An individual water accumulator in each one-family house will act as a collector for heat energy (electric energy, particularly low-tariff night time electricity, oil heating, fuel heating, solar heating, etc).

The arrangements tested on laboratory scale include: 1) One accumulator which can be heated electrically in each house combined with a fuel-fired (in the long-term possibly connected to the district heating) boiler, common to up to ten one-family houses.

2) An insulation system for the distribution pipework between the joint boiler and the individual one-family houses. 3) Various accumulator designs aimed at promoting efficiency. 4) A number of different hot-water heating arrangements suitable for connection to the accumulator. 5) An arrangement for using the heat in the exhaust air. 6) Side-effects from 5.

SUPPORTED BY Statens Rad for Byggnadsforskning

1.0381,

SOLAR ENERGY AND BUILDINGS - I

I. Hoglund, Kungliga Tekniske Hogskolan, Building Technology, *S10044 Stockholm 70, Sweden*

This project deals with the development of equipment for heating buildings by means of solar energy.

Scope of project: literature studies, theoretical calculations of the operational properties of the heating system, the development of computer programs for simulated operations, calculation of the efficiency and economy of various system solutions supported with relevant radiation measurements in various localities, special laboratory studies and tests of collectors, control equipment, thermal storage, etc., with the aid of photo-chemical reactions, heat pumps and low temperature radiators, the weather resistance and optical properties of plastics, the radiation physics of selective surfaces, an investigation of water, air and some radiation-absorbent fluid as transport media. The architectural adaption of the solar collectors to the building and the urban environment will be investigated for new constructions and existing constructions. Using a knowledge of the properties of the system components as a basis, single-family houses of 125-150 square meters will be designed with solar heating. The literature studies and the results from the investigations carried out in this project will be documented in a catalogue entitled 'Methods and materials' adapted for design. An effort will be made in the project to collaborate nationally and internationally with specialists in various fields of research. A valuable body for international exhange is 'The Solar Energy Society' in which Hoglund has been requested to form a Swedish or Scandinavian section.

SUPPORTED BY Statens Rad for Byggnadsforskning

1.0382,

SOLAR ENERGY AND BUILDINGS - II

G. Wettermark, Kungliga Tekniske Hogskolan, Physical Chemistry, *S10044 Stockholm 70, Sweden*

This project deals with the development of equipment for heating buildings by means of solar energy. This is the second stage of the project.

Scope of project: literature studies, theoretical calculations of the operations properties of the heating system, the development of computer programs for simulated operations, calculation of the efficiency and economy of various system solutions supported with relevant radiation measurement in various localities, special laboratory studies and tests of collectors, control equipment, thermal storage, etc., with the aid of photo-chemical reactions, heat pumps and low temperature radiators, the weather resistance and optical properties of plastics, the radiation physics of selective surfaces, an investigation of water, air and some radiation physics of selective surfaces, an investigation of water, air and some radiation-absorbent fluid as transport media. The architectural adaption of the solar collectors to the building and the urban environment will be investigated for new constructions and existing constructions. Using a knowledge of the properties of the system components as a basis, single-family houses of 125-150 square meters will be designed with solar heating. The literature studies and the results from the investigations carried out in this project will be documented in a catalogue entitled 'Methods and materials' adapted for design. An effort will be made in the project to collaborate nationally and internationally with specialists in various fields of research. A valuable body for international exchange in 'The Solar Energy Society' in which Hoglund has been requested to form a Swedish or Scandinavian section.

SUPPORTED BY Statens Rad for Byggnadsforskning

1.0383,

AIR-COOLED SOLAR ENERGY SYSTEM FOR SMALL HOUSES (STAGE 2)

H. Ottosson, Kvissberg & Backstrom Byggn Ab, *Box 1055, S58110 Linkoping, Sweden*

OBJECTIVES: 1) To develop new building components and methods with the aim of constructing a prototype house or groups of houses which complies with the new building code - with special emphasis on tightness and insulation. 2) To utilize an air heating system with the aim of investigating what potential energy savings can be made by taking advantage of such effects as heat exchange from ventilated air, ventilation and heating according to need, and energy from an air-cooled solar collector system. 3) To use mathematical models in order to study the dynamics of room heating, where the rock-bin storage and solar collector system are important components.

APPROACH: The project has been divided into 4 stages: Stage 1: Preliminary investigation concerning solar collector surfaces and storage possibilities, visits to industries. Stage 2: Prototype tests concerning building elements and methods, solar collectors and storage systems. Stage 3: Production of two test houses. Stage 4: Production of a group of houses for system evaluation.

PROGRESS: Stage 1 - concluded. Final report available. Stage 2 Production of test construction consisting of a roof (2x55 square meters) on a I-high wall structure is in progress. The energy storage (30 cubic meters) is built simultaneously. The measurements will be initiated in April.

INTENDED USE OF RESULTS: The results will be applicable to both new and existing buildings with air heating systems (offices, industries, etc.).

SUPPORTED BY Styrelsen for Teknisk Utveckling

1.0384,

PROTOTYPE TEST ON AN AIR HEATED, BALANCED VENTILATION SYSTEM RECEIVING ADDITIONAL ENERGY THROUGH SOLAR COLLECTORS

H. Ottosson, Kvissberg & Backstrom Byggn Ab, *Box 1055, S58110 Linkoping, Sweden*

OBJECTIVE: To study a low energy system for air heating of buildings and in a full-scale experiment perform systems analyses as well as investigations in connection with regulating techniques in balanced ventilation systems.

APPROACH: Previous work was mainly concerned with tests on solar collectors and energy storage components. By adding a floor to the existing construction, it will be possible to make realistic tests on new construction resembling a house without a basement. The apparatus room, on the ground floor, will be equipped with all of the components needed for a complete balanced ventilation system. This will make it possible to study space requirements and possible complications with regard to ducts. The collector distribution system as well as the supply air equipment will be tested on upper floors. The ventilation system includes a heat exchanger and a supplementary heater unit. Tests on different regulating methods may be carried out.

PROGRESS: The work will begin in September. Important partial results should be obtained by the turn of the year. The final report is expected to be submitted in spring 1978.

INTENDED USE OF RESULTS: Thanks to experience gained by these tests it will be possible to make a more accurate assessment of the function and characteristics of air heated, balanced ventilation systems.

SUPPORTED BY Styrelsen for Teknisk Utveckling

1.0385,

PROGRAM WORK FOR SIMULATING AND CARRYING OUT MEASUREMENTS ON BUILDINGS WITH UNCONVENTIONAL ENERGY SYSTEMS

B. Adamson, Lunds Universitet, School of Technology, Building Science, *Box 725, S22007 Lund 7, Sweden*

Program work for: Investigating the possibilities for designing general simulation program for buildings with unconventional energy systems with solar heat collectors, storage, greenhouses, composting rooms, heat pumps etc.

The design of the R and D programs concerning: 1. Simulation studies of buildings with unconventional energy systems. 2. Studies of how full-scale pilot houses with unconventional energy systems should be designed.

PROGRESS: The research work is concluded. Report is available.

SUPPORTED BY Statens Rad for Byggnadsforskning

1.0386,

LOW-ENERGY CONSTRUCTION

B. Adamson, Lunds Universitet, School of Technology, Building Science, *Box 725, S22007 Lund 7, Sweden*

Within the framework for the project 'Low-resource construction', the Department of Building Function Theory intends to carry out work concerning energy conservation in conjunction with the buildings (heating, ventilation and lighting).

This work consists of: 1. An inventory of heat exchange systems, low-energy lighting systems, control systems, systems for making use of solar and sky radiation, low-energy greenhouse designs for compost reactors, local energy storage systems. 2. Writing a universal computer program covering heat balance calculations for building designs containing the systems mentioned above. 3. Carrying out calculations using the computer program mentioned above for optimizing purposes and for systems studies.

This work is broken down in the joint project description into projects with the designations BKL 1... BKL 15.

SUPPORTED BY Statens Rad for Byggnadsforskning

1.0387,

FURTHER DEVELOPMENT OF COMPUTER PROGRAM CONCERNING ENERGY FOR ONE-FAMILY HOUSES

B. Adamson, Lunds Universitet, School of Technology, Building Construction, *Box 725, S22007 Lund 7, Sweden*

An increased exchange of material with Japanese research and technology in the field of climate conditioning and services is extremely important. Professor K. Kimura at Waseda University has proposed a Japanese research worker who has spent the last three years in the technical research institute of a major Japanese firm, for collaboration at the Department of Building Function Theory for a period of two years. His duties there would be partly to work out computer programs for air-air and air-water heat pumps, solar heat collectors with storage units and heat storage in the ground, and partly to draw up a summary of the present position with regard to research and technology in Japan concerning climate conditioning in buildings.

SUPPORTED BY Statens Rad for Byggnadsforskning

1.0388,

LOW-ENERGY BUILDING

B. Adamson, Lunds Universitet, School of Technology, Building Science, *Box 725, S22007 Lund 7, Sweden*

The Department of Building Science intends to carry out work within the framework for the project 'Low-resource building' concerning energy conservation in conjunction with buildings (heating, ventilation and lighting).

This work consists of: 1. An inventory of heat exchange systems, low-energy lighting systems, control systems, systems for utilizing solar and sky radiation, low-energy greenhouse designs, composting reactors, local energy-storage systems. 2. Writing a universal computer program for thermal balance calculation for building designs embracing the systems inventoried above. 3. Carrying out calculations with the above mentioned computer program for optimization and system studies.

SUPPORTED BY Statens Rad for Byggnadsforskning

1.0389,

THE SOUTH BALTIC HOUSE - URBAN BUILDING STUDIES

B. Hulten, Lunds Universitet, School of Technology, Town Planning A, *Box 725, S22007 Lund 7, Sweden*

These studies are intended to lead to experiments dealing with the local supply of solar heat for heating purposes and the local supply of water to a neighborhood block as well as testing the requirements which emanate from waste water seepage. The emphasis will be on solar heating and spatial design. House types and flat solutions will be studied as will sections, entrance conditions, etc.

SUPPORTED BY Statens Rad for Byggnadsforskning

1.0390,

TOWN PLANNING FOR RESOURCE CONSERVING CONSTRUCTION

C.H. Olsson, Lunds Universitet, School of Technology, Town Planning A, *Box 725, S22007 Lund 7, Sweden*

This project is broken down into the following main parts: Town planning geometry I- incident sunlight on external walls within town plans; Town planning geometry II- surfaces for solar collectors and heat magazines etc; inventory- studies of conditions in Lund and Pitea; program stage- prerequisites for town plans and sketches; sketches for town plans- studies of area requirements, checks; of inventories and programs, source material for town planning proposals; proposals for resource- drawing up 2 to 4 town planning proposals; conserving town plans- a synthesis of the preceding work.

SUPPORTED BY Statens Rad for Byggnadsforskning

1.0391,

ENERGY-SAVING SYSTEM FOR HEATING AND VENTILATION BY CIRCULATION OF AIR THROUGH NILCON BEAMS

S. Nilsson, Nilcon Engineering Ab, *Box 56, S43050 Kallered, Sweden*

The Nilcon unit, which is based on a prestressed concrete construction system, consists of two components, a loadbearing cassette component and a lock component. Owing to the construction of the Nilcon unit, special advantages can be obtained relating to the use of circulating air for heating and ventilation purposes, one of the reasons being that no ducts are needed for the distribution of hot air and ventilation air. The basic features of a heating and ventilation system based on the Nilcon beam have been tested in a number of building types such as single-family houses, blocks of flats, and schools.

The need for considerably reduced energy costs in excess of 30% has resulted in various ideas for the improvement of the system. In order that the system may be finally developed, it is necessary to test certain theoretical and practical basic data relating to the dimensioning of the heating plant and to the adaption of the apparatus to the Nilcon system. The object of this project is to test different solutions for the reduction of heat transmission losses and ventilation losses and for the utilization of solar radiation and low-heat water from district heating plants in the optimum manner. Reduction of the energy requirement must not have an adverse effect on dwelling comfort.

It is planned to carry out the project in three integrated subprojects: Project A: Detailed tests to provide data for the dimensioning of heating plants and apparatus; Project B: Development of hot air unit; Project C: Full-scale tests.
SUPPORTED BY Styrelsen for Teknisk Utveckling

1.0392,

STUDY CONCERNING THE LOCATION OF LARGE SOLAR HEAT CENTERS

J. Lilja, Ostgotabyggen Ab, *Box 9001, S58009 Linkoping, Sweden*

OBJECTIVES: Introductory study for the suitable location of a solar heating center consisting of a central building with one or more accumulators located underground and/or in underground rock. The center will be a supplement to, or a replacement for a district heating plant for both existing and future multi-family and one-family houses.

APPROACH: Existing maps, drawings, reports on existing and future buildings and energy requirements will be studied together with the parties concerned. Energy conservation, heat recovery, low-temperature systems and other related factors will be reviewed.

PRESENT SITUATION: Experience from the implementation of Stage 1 and design work of Stages 2 and 3 such as solar collectors, system solutions, geotechnical studies and the design of a heat accumulator as well as buildings are available.

APPLICATION OF RESULT: The result of the introductory study will consist of one or two alternative proposals for the location of a building for a solar heating center and one or more underground heat accumulators in soil or rock. The results of project should be of importance for other similar projects when these results have become known within a year or so and will thus constitute a contribution to the energy supply in Sweden.

SUPPORTED BY Statens Rad for Byggnadsforskning

1.0393,

LOW-ENERGY HOUSES - INVESTIGATIONS INTO A PRACTICAL TESTS ON SOLAR ENERGY FOR ONE-FAMILY HOUSES

G. Torneback, Ostgotabyggen Ab, *Box 9001, S58009 Linkoping, Sweden*

The purpose of this project is to build a solar energy system, which can contribute 40-60% of the energy requirements for heating and domestic hot-water for a traditional one-family house.

This pilot project should provide experience for building a large, joint heating plant for several houses and for developing newer, simpler and cheaper solar heat collectors and better accumulators.

SUPPORTED BY Statens Rad for Byggnadsforskning

1.0394,

PRESTUDY ON COMBINED SUN-ENERGY SYSTEMS FOR HEAT AND ELECTRICITY PRODUCTION

D.J. Braun, Studsvik Energiteknik AB, Industrial Energy Section, *S61182 Nykoping, Sweden*

OBJECTIVE: Analysing the technical-economical possibilities for converting sun energy to electric energy and process heat for industrial, agricultural and forestry use.

APPROACH: Units of 10 MW correspond to actual needs and will therefore be studied. The study covers the following issues: 1) Applications; 2) Energy forms and effect/energy criteria; 3) System designs at different temperatures; 4) Solar energy systems and conventional systems interaction; 5) Technical-economical analysis.

INTENDED USE OF RESULTS: The findings will be used in the Board's R & D planning and decision making.

SUPPORTED BY Namnden for Energiproduktionforskning

1.0395,

COMBINED ACCUMULATOR AND SOLAR COLLECTOR FOR GROUPED ONE-FAMILY HOUSES

R. Roseen, Studsvik Energiteknik AB, *S61182 Nykoping, Sweden*

This project aims at producing a long-term accumulator for hot water with a solar collector suitable for one-family house groups of 50-300 units. The system is estimated to be capable of covering the all-year-round heating requirements for new group houses and 90 percent of the requirements in existing houses with poorer insulation. In the main, the system consists of a cylindrical hole in the ground sealed with rubber cloths which are pressed against the insulation and a floating tops insulation. The solar collector construction is arranged on the top insulation. The insulation and the solar collector can be made rotatable so as to utilize the optimum angle of incidence. This reduces the reflection loss and facilitates the use of mirrors or the design of a solar collector with moderate concentration. As a result, high system efficiency is expected even at high operating temperatures (approximately 60 degrees C). The project refers to system studies, preliminary investigations and testing a prototype.

The project is to result in the production of basic materials for demonstration plant.

SUPPORTED BY Statens Rad for Byggnadsforskning

1.0396,

PILOT HOUSE FOR COORDINATED RESEARCH ON LOW-ENERGY HOUSES, PROJECT TABY

N. Lindskoug, Styrgruppen for Projekt Taby, *S10340 Stockholm, Sweden*

25 houses provided with installations for measurements will be used to give answers to the following questions: How far will we get using 'Swedish Building Norm 75 - energy conservation' only? Can the application of known technology - ventilation, control of temperatures and air flows - give significant improvements? Where does solar heat and heat pump technology stand in relationship to this?

Marginal adjustments can be carried out by simulating the operation of all houses in a computer. The statistical evaluation will provide results which individual houses cannot give, namely variance around observed mean values.

SUPPORTED BY Statens Rad for Byggnadsforskning

1.0397,

ENERGY STORAGE - A STUDY OF SWEDISH DEMAND FOR ENERGY STORAGE AND AVAILABLE TECHNIQUES

L. Ojefors, Svenska Utvecklings Ab, Energy & Environ Technology, *Box 210 48, S10031 Stockholm, Sweden*

The study will analyze the demand of energy storage in the Swedish energy production system, today and in the future. The study will concern heat and electricity storage in the energy production sector, such as wind power plants, district heating plants, large solar plants etc. Energy storage applications such as single dwellings or buildings or similar will not be dealt with in this investigation.

The design of Swedish electricity production system will influence demand and profitability and demand of electricity energy storage. Sweden has at present a production system based on hydropower and this will reamin for a long period of time. Due to this fact experience from fossil-fuel production system is not applicable to the Swedish system.

The study will further concern how the choice of future electricity and heat production will effect economy and demand of central and local energy storage.

The investigation will include a systematic study of the demand for electricity and heat during the year, week and day for industries, dwellings and offices.

Different techniques for energy storage have been studied at Swedish and foreign institutions, and will not primarily be considered in the first phase of this project. Available information will be used to form an opinion of which energy storage systems are suitable for Sweden.

SUPPORTED BY Namnden for Energiproduktionforskning

1.0398,

INVESTIGATION PROGRAM CONCERNING ENERGY ECONOMY IN GREENHOUSES

J. Alemo, Swedish University of Agricultural Sciences, Farm Buildings, *Box 624, S22006 Lund 6, Sweden*

The fuel consumption for heating greenhouses is considerable. This is the reason why, in recent years, a number of ideas aimed at reducing heat consumption have been launched in step with rising oil prices. The Department of Agricultural Building Technology, the Agricultural College of Sweden, and the Department of Building Construction, the Lund Institute of Technology, therefore find it important that thorough analysis be made of the theoretical and practical issues relating to energy consumption in greenhouses.

The object of this project is to provide data which may serve as basis for the continuation of a research activity program within this field.

SUPPORTED BY Styrelsen for Teknisk Utveckling

1.0399,

ENERGY CONSERVING THERMAL INSULATION

R. Henriksson, Swedish University of Agricultural Sciences, Agricultural Building Technolo, *Box 624, S22006 Lund 6, Sweden*

Theoretical analyses are to be carried out on thermal insulation in animal stables with regard to all enclosing surfaces and with regard to ventilation. The objective is to be able to provide constructive directives with a view to saving energy in an economic manner. In a later part, the investigation is intended to establish the faults which are made when installing thermal insulation so as to be able to provide directives which will ensure that the insulation has the intended effect.

The project embraces: 1) A calculation of economic thermal insulation with regard to the varying heat and moisture production of the animals. 2) A determination of the actual thermal insulation values for various building constructions in animal stables with regard to the workmanship. 3) Drawing up guidelines for thermal insulation with regard to all enclosing surfaces, ventilation and real thermal insulation value. 4) Drawing up directives for insulation work.

SUPPORTED BY Statens Rad for Byggnadsforskning

1.0400,

USE OF SOLAR COLLECTORS FOR THE PURPOSE OF SAVING ENERGY WHEN DRYING GRAIN AND HAY

I. Jansson, Swedish University of Agricultural Sciences, Farm Buildings, *Box 624, S22006 Lund 6, Sweden*

OBJECTIVE: To develop solar collectors for air heating, with a view to connecting these to new or existing plants for drying grain and hay. The solar collectors are to be made of conventional building material to give simple and inexpensive construction. They are to form an integral part either of the roof or the walls of the drying plant.

APPROACH: The solar collector-drying plant unit must be designed to give optimum utilization of the collected energy with regard to the biological requirements of the material to be dried. The energy-collecting capacity of various kinds of solar collectors will be determined for various degrees of cloudiness (drying demands not necessarily being heavier on a cloudless day), various quantities of air passing through the solar collector, and different angles of the absorbent, etc. To prevent over-drying, the air should not be heated more than 5 to 7 degrees C. The drying-process is therefore affected by incoming radiation varying with the sun's altitude and also by the heat capacity of the grain or hay, which tends to store heat.

PROGRESS: The Department has studied four different solar collector prototypes made of plastic and using various absorbents, as well as two solar collectors of simple design using the roof surface of asbestos cement and sheet metal as the absorbent. Two years' observations made July 15 - September 15 have been analyzed and are to form the basis of pilot plants and full-scale systems.

INTENDED USE OF RESULTS: The results of this project will be published, providing complete engineering recommendations for the solar collector-drying plant system.

SUPPORTED BY Styrelsen for Teknisk Utveckling

1.0401,

WIND SCREENS FOR GREENHOUSES

B. Landgren, Swedish University of Agricultural Sciences, *Box 624, S22006 Lund 6, Sweden*

A considerable proportion of the greenhouse stock in Sweden is located in flat, windy countryside such as Skane and along the west coast. Bearing in mind the fact that heating costs for market gardening have more than tripled in the last few years, the need to reduce consumption for these particularly exposed facilities is extremely large.

The purpose of this project is to shed light on lee effects and practical heat savings with the aid of various types of artificial wind shelters. Shadowing effects will also be recorded and an evaluation will be carried out for various areas in Sweden with regard to statistical meteorological data.
SUPPORTED BY Statens Rad for Byggnadsforskning

1.0402,
ACCUMULATION OF ENERGY IN GREENHOUSES

B. Landgren, Swedish University of Agricultural Sciences, Farm Buildings, *Box 624, S22006 Lund 6, Sweden*

OBJECTIVE: To develop and evaluate methods, primarily for short-time accumulation of excess energy in greenhouses, from the daytime to the following night. Long-time storage, from the summer to the winter season, will also be the subject of a preliminary investigation.

APPROACH: Various methods of accumulation will be investigated by means of literary studies concerning methods for collecting energy, transformation of energy, storage principle, storage location and design, etc. After the construction and testing a prototype, an over-all techno-economic evaluation will be made.

PROGRESS: The tests made so far at a greenhouse establishment at Alnarp, using a provisional water basin, have produced extremely positive results which will form a basis for the continuation of work. It seems that a combination of solar collectors and heat pump, together with effective accumulation, will make it economically possible to reduce the energy consumption of greenhouses by 70-80%, compared to the present consumption of the conventional greenhouse.

INTENDED USE OF RESULTS: Swedish greenhouse production, entailing approximately 2,600 enterprises consumes between 70-90 litres of oil per year (approximately 30-40 Skr/m2 year) in heating houses. A prerequisite for the continuation of Swedish greenhouse production is that energy consumption may be radically reduced.

SUPPORTED BY Styrelsen for Teknisk Utveckling

1.0403,
PROTOTYPE HEAT PUMP SUITABLE FOR USE IN STABLES

A.G. Martensson, Swedish University of Agricultural Sciences, Farm Buildings, *Box 624, S22006 Lund 6, Sweden*

This project embraces the construction of a prototype heat pump to be used in stables.

At the Department of Farm Buildings, with a grant of SKr 250,000, the project 'Saving of energy by use of heat pumps in farm buildings' is being carried out over the three-year period 1974/77. Calculations show that the heat present in the air discharged from stables can be utilized for heating purposes. A stable for 20 cows, for instance, provides 14,000 kWh/year. However, the air discharged from stables contains large quantities of dust, 1-5 mg/cubic meter. This places unusually great demands on the engineering construction of the heat pump, and this is the reason why the equipment now available commercially does not work satisfactorily.

In order to develop the heat pump for the specialized use in stables, a draft program has been drawn up which requires testing, at full scale, of specially developed equipment.

Development work is done in collaboration with Klimatkyla AB.

The construction of a prototype and prototype tests are expected to be accomplished during 1975/76.

SUPPORTED BY Styrelsen for Teknisk Utveckling

1.0404,
PREHEATING VENTILATION AIR IN STABLES WITH THE AID OF SOLAR COLLECTORS

G. Gustafsson, Swedish University of Agricultural Sciences, Faculty of Agriculture, Farm Buildings, *Box 624, S22006 Lund 6, Sweden*

OBJECTIVE: The objective is to reduce energy requirements for heating stables by preheating the ventilation air with the aid of solar collectors. This will include the development and testing of simple solar collectors with regard to function and construction. The function of solar collectors with small pitches and vertical solar collectors facing the south will be studied. Solar collectors will be adapted to the various climatic requirements of stables. A suitable control system for this type of heating will be developed. Application experiments with solar collectors for controlling the climate in stables will be carried out.

APPROACH: The project will be introduced with a determination of the heating requirements of the various stables with regard to annual and 24-hour variations. At the same time, long-term experiments will be carried out with simple model solar collectors to provide design material for various stable types. Application experiments will then be made for developing control technology and for studying the climate in stables. Continuous climatic experiments with stables are carried out at the Department of Farm Buildings. In addition, the development of simple solar collectors for drying purposes has been in progress in the Department since 1975.

PRESENT SITUATION: The basic know-how and experiment technology within the fields of climate control for stables and solar collectors for heating air are available at the Department.

USE OF RESULTS: The project results are intended for use in farms where breeding is carried out, particularly sow and broiler breeding, saving of 29% in heating stables corresponds to 12,000 cubic meters fuel oil per year.

SUPPORTED BY Statens Rad for Byggnadsforskning

1.0405,
HEAT ENERGY ACCUMULATOR FOR HOUSE HEATING REQUIREMENTS FOR ONE YEAR

K. Bakken, Tepidus Ab, Research Station, *Box 5607, S-114-86, Stockholm, Sweden*

OBJECTIVE: To solve the problem of storing enough thermal energy to cover house heating requirements for one year. The principal energy source will be solar energy and, in second place, the use of industrial waste heat.

APPROACH: The problem will be solved with the aid of a chemical heat pump (a two-chamber system with distillation storage by the use of water vapor). As the thermal energy is converted into chemical energy, storing is possible for an unlimited period of time, and when needed the chemical energy is reconverted again into thermal energy. The principle has been known for a long time but not unitl 1977 did it find practical application and a pilot system was built. Solar collectors supply energy to a substance which is capable of storing and 'pumping' an amount of energy of 1 kWh/kg of the substance in question. Accordingly, in order to store enough energy to satisfy the heating requirements for one year of a well insulated Stockholm house, using solar collectors as energy source, 7-10 tons of substance would have to be supplied. The substance may also be transported to a waste heat source, where it is 'charged', and then transported back.

PROGRESS: The system, has been in operation for about 3/4 of a year in a house with an area of 50 sq. m. The system is about to be developed further, in that a full-scale unit will be constructed and installed in a house, whose heating requirements are 15-20,000 kWh per annum, domestic hot water included. Solar collectors will be used for supplying energy.

INTENDED USE OF RESULTS: The result of this project will provide basis for production of heat energy storage systems for use in houses.

SUPPORTED BY Styrelsen for Teknisk Utveckling

ENERGY PRODUCTION FROM BIOMASS

2.0001,
PRODUCTION OF SUGARCANE AND TROPICAL GRASSES AS A RENEWABLE ENERGY SOURCE

A.G. Alexander, University of Puerto Rico, Mayaguez Campus, Agricultural Experiment Station, Dept. of Agronomy & Soils, *Mayaguez, Puerto Rico* 00708 (PR-C-00481)

OBJECTIVE: Determine the agricultural and economic feasibility of mechanized, year-round production of dry biomass, through the intensive management of surgarcane and napier grass as tropical forages; examine alternate tropical grasses as potential sources for intensive biomass production; and select and breed new sugarcane clones having superior biomass productivity as their main attribute.

APPROACH: In greenhouse trials, tropical grass species having superior growth potential (on an annual basis and as frequently recut forages) will be identified. Optimal regimes for nitrogen, water, row spacing, harvest frequency, and chemical growth regulators will be defined with superior candidate clones in field plot trials. Mechanization requirements and costs for the two or three superior candidate clones emerging from greenhouse and field-plot experiments will also be evaluated in field trials.

SUPPORTED BY Puerto Rican Government

2.0002,
PACKED-BED REACTORS FOR CONCENTRATED WASTE TREATMENT AND ENERGY PRODUCTION

K.B. Pedersen, University of Puerto Rico, Mayaguez Campus, School of Engineering, Dept. of Nuclear Engineering, *Mayaguez, Puerto Rico* 00708

A packed-bed reactor is proposed for the simultaneous treatment of wastes and for energy production. The project will consist of two phases, each of approximately one year's duration.

The first phase is a continuation of an ongoing project in which domestic sewage is fed as activated sludge to an anaerobic filter (a packed-bed, upflow reactor). The ongoing project has shown the process to be successful in some aspects of the treatment, e.g. there is some decrease in the COD and a marked decrease in volatile acids, as well as in the production of relatively large amounts of methane gas.

For the first phase it is proposed that the feed to the filter be gradually changed from activated sludge to raw sewage while keeping the biological load approximately constant. Once the filter has achieved equilibrium under the new conditions, other parameters, such as temperature and hydraulic retention time, will be varied to achieve optimum conditions. This phase is proposed to last approximately one year.

A facility integrating the filter into a sewage treatment plant for the simultaneous treatment and recovery of methane will be proposed.

The second phase to be of about the same duration will apply the anaerobic filter process to a local source of industrial waste, specifically the tuna packing industry. Because of the high organic loading and small amounts of undissolved solids contained in these wastes, it is expected that they will lend themselves excellently to this type of treatment.

SUPPORTED BY U.S. Dept. of the Interior, Office of Water Research & Technology

2.0003,
CONVERSION OF CELLULOSIC AND WASTE POLYMER MATERIAL TO GASOLINE

J.L. Kuester, Arizona State University, School of Engineering & Applied Sciences, Dept. of Chemical Engin, *Tempe, Arizona* 85281 (EY-76-5-02-2982)

The project is aimed at the conversion of cellulosic or waste polymer materials to liquid, transportable fuels. The cellulose source may be from urban refuse, agricultural or forest residues or from crops deliberately grown for energy conversion purposes (land or marine). Since cellulose (biomass) is obtained by photosynthesis (carbon dioxide water sunlight), the project is solar in nature and the feedstock (plant material) is considered a renewable resource. The process involves decomposing the feed material to basic compounds under the influence of heat (pyrolysis). The basic compounds are then introduced into a chemical reactor where a diesel or jet fuel type material is produced. If a high octane gasoline is desired, a final reaction step is used (reforming).

SUPPORTED BY U.S. Dept. of Energy

2.0004,
POTENTIAL ENERGY EQUIVALENTS OF VEGETATION TYPES IN ARIZONA

P.F. Ffolliott, University of Arizona, School of Agriculture, Renewable Natural Resources Division, *Tucson, Arizona* 85721 (ARZT-0206-4168-220)

OBJECTIVE: This study will derive estimates of the energy equivalents of standing biomass in the vegetation types of Arizona; derive estimates of the energy equivalents of residues associated with current land management practices implemented in these vegetation types; and identify energy equiv-

alents of standing biomass and management residues associated with alterntive land management practices commonly implemented in the respective vegetation types.

APPROACH: Energy equivalents of standing biomass will be determined from extent of area in type, spatial densities of vegetation, rate material growth, specific gravities, and appropriate conversion values. Energy equivalents of management residues will be estimated from knowledge of volumes of residues, specific gravities, and appropriate conversion values. Three levels of biomass energy availabilities will be appropriate conversion values. Three levels of biomass energy availabilities will be generated for each vegetation type: Low, mean (most commonly encounted), and high.

SUPPORTED BY Arizona State Government

2.0005,

GROWTH/YIELD AND ENERGY POTENTIAL OF NATURALLY OCCURING BOTTOMLAND STANDS OF SOUTHERN HARDWOODS

M.S. Fountain, University of Arkansas, Monticello Campus, Undergraduate School, McIntire Stennis Program, *Monticello, Arkansas* 71655 (ARK00949)

OBJECTIVE: Determine the total above ground biomass of selected commercial and non-commercial hardwood species and the percentage of the total aboveground biomass contained in the various tree components; develop prediction equations for green and dry weight of total trees and tree components and volvumes of each species; develop polymorphic site index curves from stem analysis data for various commerial hardwood species; and develop growth/yield tables for unmanaged bottomland hardwood stands.

APPROACH: Field collection of data will be accomplished in two phases. Data for the development of weight tables for the various species will be obtained by destructive sampling of trees from diameter classes representative of the range for each species. Growth/yield information will be obtained from 1/5-acre plots located so as to sample stands representative of the various age class-site type combinations found in this region.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Arkansas

2.0006,

EXPERIMENTAL PROGRAM FOR THE ALBANY, OREGON WASTE-TO-OIL EXPERIMENTAL FACILITY

S. Ergun, Bechtel National Inc., Scientific Development, *50 Beale St., P.O. Box 3965, San Francisco, California* 94119 (E(04-3)-1338)

An experimental facility is being constructed at Albany, Oregon for gasification of lignocellulosic biomass to produce fuel oil. This facility will be operated to demonstrate the PERC process resulting from research by the U.S. Bureau of Mines. Objectives of this project are: (1) to assess technical and economic feasibility; (2) to improve or optimize key steps in the process; (3) to evaluate performance of equipment; and (4) to attempt alternative processing steps when the original designs are impractical. Problems are anticipated in conveying materials at the high temperatures and high pressures required for oil formation. Lock hoppers have not been used previously under such severe conditions, and modifications are likely to be required. Start-up and initial operations will emphasize wood chips or wood flour as the biomass input, but agricultural crops or residues will also be tested. Flow rates, oil recycle rates, heating rates, temperatures, pressures, and proportions of hydrogen and carbon monoxide will be varied. Yields of oil, yields of byproducts such as char, and product characteristics will be determined. (ERDA 76-137)

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0007,

TECHNICAL EVALUATION OF THE WASTE-TO-OIL EXPERIMENTAL FACILITY IN ALBANY, OREGON

E.H. Houle, Bechtel National Inc., *50 Beale St., P.O. Box 3965, San Francisco, California* 94119 (E(04-3)-1194)

The objective is to determine acceptability of the Albany, Oregon experimental facility for producing oil by gasification of cellulosic materials. This study will: (1) review the modifications required at the plant and assess their facility; (2) assess the feasibility of using the feed preparation and storage elements, general support facilities and other ancillary equipment with other process schemes and estimate the cost of plant additions and modifications; (3) review the environmental problems associated with the pilot plant and recommend modifications to meet these problems; and (4) insure that all construction specifications have been met. (ERDA 76-137)

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0008,

MACROECONOMIC STUDY - BIOMASS VS. COAL

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The contractor is to compare multimedia environmental impacts and the cost of clean energy generation from the production and utilization of synthetic fuels from biomass, from biomass energy crops and from coal. A report on pollutant emissions and control technology assessment will address the economic and environmental comparisons of coal use versus synthetic fuels from biomass versus using 'energy crops' directly from energy generation. Crop types receiving attention include agricultural crops (marsh plants, sugar cane, sugar beets, etc.) silvicultural crops (various high-volume production tree crops, other forest material, etc.); and aquacultural crops (hyacinth, seaweed, algae, kelp, etc.).

In general, processes under development in waste-as-fuel research will probably be applicable to any biomass or biomass-derived feedstocks. Therefore, the applicability of existing processes will be evaluated, emphasizing technology requirements, and the costs of pollution control and energy production will be compared to that of coal.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Industrial Environmental Research Lab.

2.0009,

EVALUATING OCEANIC FARMING OF SEAWEEDS AS SOURCES OF ORGANICS AND ENERGY

W.J. North, California Inst. of Technology, Graduate School, Dept. of Engineering & Applied Science, *1201 E. California Blvd., Pasadena, California* 91109 (E(04-3)-1275)

Cal. Tech. proposes to conduct detailed physiological studies of kelp growth as it may be influenced by the chemical and physical environment. Researchers will test a range of mixtures of deep and surface water to determine optimum conditions for kelp growth. The mixing studies will take place at the Lamont-Doherty upwelling facility on St. Croix. Certain biometrical studies on adult macrocystis fronds collected from differing depths will be done to provide data needed for engineering design of marine farms. The bulk of the physiological work will be performed under controlled conditions in the laboratory with supporting data occasionally sought from field observations. The primary factors of interest will be water temperature and dissolved nutrients such as nitrogenous compounds, phosphate, and trace substances. Cal. Tech. will utilize juvenile Macrocystis sporophytes weighing from one to ten grams as their principal experimental material. A few ancillary studies may be conducted with gametophytes of with somewhat larger sporophytes if time permits. This project will support the A.G.A.-funded ocean farm module. (ERDA 76-137)

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0010,

CONVERSION OF BIOMASS INTO GASEOUS PRODUCTS

D.E. Garrett, Garrett Energy Research & Engineering Co. Inc., *P.O. Box 21, Claremont, California* 91711 (E(04-3)-1241)

A multiple hearth contractor for the handling, drying, pyrolysis, combustion and water gas reaction of biomass materials is being designed, built, and tested. The research will attempt to answer the questions of workability, economy, technical and economic feasibility, and the potential values of this biomass conversion process. The tasks are: Literature review of thermal biomass conversions in all types of reactions. Preliminary design of the process, including the heat and material balances. Building and operation of a small bench scale reactor for studies of the steps involved in processing biomass materials such as drying, pyrolysis, burning, and the water gas reaction, with attempts to optimize the time, temperature, and other variables for best operation. Review, evaluation, and preparation of reports. (ERDA 76-137)

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0011,

CONSTRUCTION OF WOOD WASTE-TO-OIL EXPERIMENTAL FACILITY (SYNCRUDE)

R.J. Lull, Maecon Inc., *Sante Fe Springs, California* 90670 (E(04-3)-1113)

A plant at Albany, Oregon will obtain information about the economic and technical feasibility of converting organic raw materals to oil using high pressure carbon monoxide and steam, and a sodium carbonate catalyst. The organic feeds may be wood waste, urban refuse, or agricultural materials. This plant will provide; chemical and physical data about what happens to the carrier oil, which must be recycled in a continuously operating plant; information necessary for process control. This includes the sensitivity of the process to operating variables such as temperature and pressure, and the instrumentation necessary to control these variables; data on the residence time, quantity of catalyst needed, and system throughput; direct operating experience with a continuous system that is original in concept; vital information about environmental considerations associated with this process. (ERDA 76-137)

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0012,

AN EVALUATION OF THE USE OF AGRICULTURAL RESIDUES AS AN ENERGY FEEDSTOCK - AN EXTENSION OF WORK

J.A. Alich, S R I International, *300 Ravenswood Ave., Menlo Park, California* 94025 (E(04-3)-115)

This project is concerned with evaluating the technical and economic feasibility of utilizing agricultural residues as energy feedstocks. The production of crop residues by farms, greenhouses, and the commercial forestry industry, and the production of manure by confined livestock and poultry operations has been analyzed, and a national inventory of residue production, including information on properties, quantities, distribution, and seasonality, is being conducted. To complete the assessment of the economics, logistics, and technology of utilizing residues as energy feedstocks, site visits will be made.

Additional activities include enrichment of the computer data system, documentation of the data base to insure proper use by others, and selected site system studies. The site visits will be used to characterize agricultural and industrial potentials and energy needs, and to refine the agricultural residue data. The site studies will provide methodology and data useful for developing plans for proof-of-concept experiments. Sites will be selected to provide data on a range of options rather than to solidify proof-of-contempt.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0013,

SAN DIEGO COUNTY SOLID WASTE RESOURCE RECOVERY PROJECT

C.J. Houson, San Diego County Public Works Agency, *San Diego, California* 92123

DESCRIPTION: The objectives of this project are: (a) to demonstrate that the proposed integrated recovery process offers a superior technical, economic, and ecological method for disposing of 200 TPD of municipal solid waste from the City of Escondido and the City of San Marcos, California; (b) to show that the production of an industrial heating oil from municipal solid waste offers attractive possibilities for alleviating the nation's energy shortage, and that magnetic metals and a 99.9% pure glass cullet can be recovered for recycling into the economy; (c) to demonstrate the suitability of the process for conversion of special wastes such as used tires, animal waste, and sewage sludge into marketable products; (d) to identify those solid wastes which can produce char which is capable of being converted into low cost replacement form of powdered, activated carbon for the treatment of secondary sewage effluent and water filtration.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development

2.0014,

HEAT TREATMENT OF REFUSE FOR INCREASED ANAEROBIC BIODEGRADABILITY

P.L. McCarty, Stanford University, School of Engineering, Dept. of Civil Engin, *Stanford, California* 94305 (E(04-3)-326)

Experiments will be run to establish the increased biodegradability and methane production from waste organic materials by heat treatment under pressure. The materials under study include farm residues, forest product wastes, and municipal wastewater sludges. The aim is to develop a general model for heat treatment which is applicable to all organic materials.

The major variables proposed for study are temperature of treatment (25 degrees to 250 degrees), time of treatment (0 to 3 hours) and pH (1 to 13). Based on ongoing studies, heat treatment is expected to solubilize and simplify the structure of wastes which increases the biodegradability significantly. The heat treatment process is expected to be compatible with the normal process train through which organic materials are digested for conversion to methane gas.

The increase in biodegradability through heat treatment will be assessed initially through short term anaerobic bioassay procedures. Once optimum conditions for heat treatment are found, then bench scale anaerobic digestion and heat treatment systems will be evaluated with the various wastes in order to determine the overall benefits which will result. Among the increased benefits anticipated are increased methane yield per unit of waste treated, reduced costs for methane production, and a lower quantity of more readily dewatered residue for ultimate disposal.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0015,

HEAT TREATMENT OF REFUSE FOR INCREASING ANAEROBIC BIODEGRADABILITY

P.L. McCarty, Stanford University, School of Engineering, Dept. of Civil Engin, *Stanford, California* 94305

Description: Anaerobic treatment of refuse has potential of producing methane gas for use as a fuel source. This research is concerned with evaluating the efficacy of various heat treatment procedures in converting refractory organic materials to biodegradable substances so they will be convertable to methane gas. Organic solids remaining after anaerobic digestion of urban organic refuse materials will be subjected to various temperatures ranging from 100 degrees C to 280 degress C and various pH values ranging from 1 to 13 for reaction times ranging up to 2 hours. Biodegradability will be assessed using Warburg microrespirometer and laboratory scale anaerobic digesters. Optimal treatment procedures identified during the study may be tried on undigested organic refuse and on selected agricultural materials.

Addenda: Estimated calendar year funding reported as 1974 $10,000; 1975 $38,000.

SUPPORTED BY U.S. National Science Foundation, Div. of Advanced Energy & Resources Research & Technology

2.0016,

TERRESTRIAL AND MARINE BIOMASS ENERGY OPTION FOR HAWAII OF BIOCONVERSION AND SOLID WASTE

C.R. Robertson, Stanford University, School of Engineering, Dept. of Chemical Engin, *Stanford, California* 94305

This project was an in-depth analysis of the biomass energy options for the State of Hawaii, emphasizing the 1975-1985 time-frame. The technical, economic, legal, political, social, and environmental aspects were examined. Resources considered include bagasse and other agricultural wastes, forest wastes, forest crops (including eucalyptus), sea crops (including algae and kelp), and urban refuse. The objective was to produce an integrated plan for further development and implementation of this resource within the State of Hawaii.

The study was conducted by a team of Stanford faculty and graduate students, in cooperation with a smaller team from the Hawaii Natural Energy Institute at the University of Hawaii, with guidance from appropriate groups from Hawaii and the mainland. The Stanford faculty involved have developed considerable expertise as a result of two past studies on biomass resources. This particular research project was conducted within the framework of an advanced systems design project-course at Stanford. This course has a proven style of operation and a record of effective impact outside of the university. In addition, a smaller group of advanced students at the University of Hawaii contributed through a similar project-course effort. The business management aspects of the plan were developed in conjunction with a second-year project-course in New Business Ventures in Stanford's Graduate School of Business. A final report will be published in the fall of 1976. The project was self-funded by both universities.

SUPPORTED BY Hawaii State Government

2.0017,

INVESTIGATION OF THE DESIGN AND PERFOMANCE OF A SIMPLE LIQUID PISTON HEAT ENGINE

R.B. Murrow, Technology Associates of Southern California Inc., *362 W. Garvey Ave., Monterey Park, California* 91754

The liquid piston heat engine falls within a class of engines that require no fuel. It operates on the difference between wet-bulb and dry-bulb air temperature, possibly augmented by solar radiation. If such an engine could be used to irrigate small farms in the United States and in less developed countries, it would have the distinct advantage that there is no need for petrochemical or other fuels and their transport. However, it is essential for these applications that the device be inexpensive, rugged, simple to construct and operate, free of maintenance, and longlasting. The liquid piston heat engine seems inherently capable of meeting all these requirements. However, to date it has been employed only in the operation of novelty toys. There is no evidence of an adequate understanding of the engineering principles involved to permit the construction of a reliable, cheap device capable of producing useful work output.

The purpose of this award is to provide that engineering understanding by developing performance eugations that reflect the influence of the most promising design features; predicting engine performance, and verifying these predictions and desirable design features through experiments on simple instrumented devices.

SUPPORTED BY U.S. National Science Foundation, Div. of Exploratory Research & Systems Analysis

2.0018,

EXPLORATION OF FUNDAMENTAL CHEMICAL AND PHYSICAL PROCESSES OF COMBUSTION AND EXTINGUISHMENT

A. Broido, U.S. Dept. of Agriculture, Forest Service, Pacific Southwest Forest & Range Experiment Station, *P.O. Box 245, Berkeley, California* 94701 (PSW-2103)

OBJECTIVE: Investigate the chemical laws and reactions of fire and its extinguishment; explore the physical and chemical linkages in the fire mechanism; and develop a more complete knowledge of combustion.

APPROACH: Develop new concepts and theories for mathematical models of the combustion of pure cellulose and saccharides. Develop and study analog computer simulations of these models. Study the chemical reactions and combustion characteristics in the combustion of cellulose when inorganic chemicals are added. Study effect of chemical additives on the pyrolysis and the combustion of cellulose, and on the gaseous and particulate products. Study the potential for modifying the flammability of living vegetation by adding trace elements such as phosphorous and potassium. Study the correlation between the mineral content of living and dead vegetation and the growth cycle and the flammability of selected plant species. Identify the inorganic elements or compounds which influence flammability, and study the uptake, elimination and migration of these inorganics within the plant.

PROGRESS: Flaming combustion of cellulosic fuels occurs only if the cellulose first pyrolyzes to give a sufficiently high yield of 'tars.' The principal component of the tar fraction found after the pyrolysis of pure cellulose in an inert atmosphere is levoglucosan. We have previously demonstrated that pyrolysis of either cellulose or levoglucosan treated with acid retardants yields a new constitutent of the tar fraction--levoglucosenone (1,6-anhydro-3,4-dideoxy-delta -beta-D-pyranosen-2-one). Ouantitative data on yields of this dehydration product of levoglucosan now indicate that its formation from cellulose does not proceed via a levoglucosan intermediate. In addition, although we had previously postulated that levoglucosan is not produced directly by cellulose pyrolysis, the current experiments are providing the first direct evidence of an intermediate compound in the levoglucosan-forming process. In low temperature cellulose pyrolysis, weight loss is preceded by an 'incubation' period during which the cellulose undergoes a large drop in degree of polymerization.

SUPPORTED BY U.S. Dept. of Agriculture, Forest Service, Pacific Southwest Forest & Range Experiment Station

2.0019,

METHANOL FUEL MODIFICATION FOR HIGHWAY VEHICLE USE

Unknown, Union Oil Co. of California, *P.O. Box 7600, Los Angeles, California* 90051

This effort aims to characterize the known and potential problems involved in using straight methanol and methanol/gasoline blends in prresent automotive engines; to characterize all potential fuel modifications to permit optimum use of these fuels and to evaluate the likelihood of success and relative rating of each in overcoming these problems.

SUPPORTED BY U.S. Dept. of Energy, Div. of Transportation Energy Conservation

2.0020,

SYNTHESIS AND DEGRADATION OF ORGANIC COMPOUNDS BY SAPROPHYTIC BACTERIA

H.A. Barker, University of California, Berkeley Campus, Agricultural Experiment Station, Dept. of Biochemistry, *Berkeley, California* 94720 (CA-B#-BCH-1207-H)

OBJECTIVE: Role of specific nutrients; detect growth factors; biosynthesis of cellular constituents; metabolism of specific nitrogenous substrates; fatty acid synthesis and degradation with enzymatic preparations derived from C. Kluyveri; determine large scale culture requirements for C. Kluyveri; determine and study bacteria involved and mechanism of methane production from known natural substrates; study carbohydrate and other non-nitrogenous transformations, and CO(2) utilization in relation to anaerobic production of acetic acid; study decomposition of pear waste by nitrogen fixing bacteria and nitrogen fixation in cell-free extracts of C. Kluyveri.

APPROACH: Studies of the blutamate isomerase and mesaconase reactions have been continued and studies of the enzymatic biosynthesis of coenzyme B(1)(2) from vitamin B(1)(2) have been initiated.

PROGRESS: The substrate specificity of 3-keto-5-aminohexanoate cleavage enzyme from Clostridium SB4 was investigated. Beta-Alanyl-CoA was found to substitute for L-3-aminobutyryl-CoA in the reverse reaction; the product of the reaction was shown to be 3-keto-5-aminopentanoate. Optimal conditions for storing the enzyme were determined and kinetic constants for various substrates were estimated. A butyryl-CoA: acetoacetate CoA transferase from Clostridium SB4 was further purified to virtual homogeneity; over 100 mg of enzyme having specific activity of 395 micromoles/min/mg were obtained. The enzyme has a molecular weight of about 90,000 and contains two pairs of subunits of M.W. about 22,000 and 24,000. A study of the enzymatic degradation of 3-keto-6acetamidohexanoate by extracts of Pseudomonas B4 has been started. Initially we are attempting to define conditions permitting a satisfactory rate of decomposition of this beta-keto acid.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, California

2.0021,

PYROLYTIC UTILIZATION OF ORGANIC RESIDUES--FOREST AND AGRICULTURE--FOR ENERGY AND PRODUCT RECOVERY

D.L. Brink, University of California, Berkeley Campus, Agricultural Experiment Station, Dept. of Forestry & Conservation, *Berkeley, California* 94720 (CA-F#-FPL-2905-H)

OBJECTIVE: Develop data for and design technically and economically feasible, environmentally compatible, and socially acceptable pyrolysis processes utilizing organic residuals generated in forestry and agricultural enterprises.

APPROACH: Study bench-scale pyrolysis reactor design and parameters applying appropriate analyses of uncondensed vapors, condensates, and ashes; when justified entend to larger scale experimental units.

PROGRESS: The model developed for scale-up of the UC Pyrolysis-Gasification-Combustion (PGC) process (see CRIS Report 1975) was extended to

include both first (S-1) and second (S-2) stage reactors. Material and energy balance (M & EB) are computed using PGC experimental unit data. A part of the chemical energy of the feed stock is converted by internal combustion (IC) to thermal energy to bring S-2 to the required temperature. Accordingly M and EB are determined by IC and the latter is a function of process parameters including temperature and total solids of the feed stock (i.e., specific heat and heating value), heat transferred to the feed stock in S-1, air for IC in S-2, preheating air for S-2, and heat losses from the PGCEU relative to those predicted for commercial scale plants of various capacities. The model was summarized in a paper presented to the 1976 Alkaline Pulping Conference and published by TAPPI. It was applied to scale the process to recovery from 1500 TPD of black liquor solids generaged by a 1000 ADTPD kraft pulp mill. A paper was presented to an industry-wide Forum and later published giving process flow and description, material and energy balances, estimated energy efficiencies and impact assessment relative to the kraft pulping industry and environment. The model was also applied to a system using particulate wood as fuel stock. Comparisons between the UCPGC process and a conventional hogged wood boiler, with emphasis on energy efficiency, was presented in a paper.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, California

2.0022,

GENETIC CONTROL OF YEASTS IN WINE MAKING

S. Fogel, University of California, Berkeley Campus, Agricultural Experiment Station, Dept. of Agricultural Genetics, *Berkeley, California* 94720 (CA-B#-GEN-2947-H)

OBJECTIVE: Improve wine quality and acceptability by yeast breeding; and select strains of high alcohol yield which could provide automotive fuels at commercial levels.

APPROACH: Though the role of yeasts in wine-making is widely appreciated, relatively little effort has been directed at using genetic approaches to develop yeasts that may produce higher quality wines. The genetics of yeast is firmly established and procedures for hybridizing wine yeasts with laboratory strains or with other wine yeasts are well worked out. Inter-specific hybrids that bring together different desirable qualities such as alcohol tolerance, yield, and cold-resistance will be constructed and evaluated.

PROGRESS: The genetic analysis of the Montrachet strain (522) and the Burgundy strain of Sacharromyces cerevisiae (51) previously demonstrated by us to be homothallic diploid strains has been carried forward. A considerable number of hybrids with genetically marked laboratory strains have been subjected to sporulation and subsequent tetrad analysis. The occurrence of effectively normal segregation for all markers indicates that at least fourteen chromosomes of the two wine yeasts are essentially homologous to the corresponding genomic elements in our standard laboratory strains. Further analysis and characteristics of the alcohol dyhydrogenase systems in these strains was not carried forward during the period covered. No publications are reported at this time.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, California

2.0023,

H2 EVOLUTION IN PHOTOSYNTHETIC BACTERIA

J.A. Bassham, University of California, Berkeley Campus, Lawrence Berkeley Lab., Lab of Chemical Biodynamics, *Berkeley, California* 94720

Rhodopseudomonas spheroides, a photosynthetic bacteria which requires an organic compound such as lactic acid as an electron donor, is grown on a rich medium, and then transferred to a limited medium with various substrates as electron donors. In the absence of O2 and N2 evolution of H2 is observed in the light. This process is being studied with the objective of using it as a stage in the production of H2 as an energy source. The organic substrate could be generated, for example, by photosynthesizing green algae, or by agricultural wastes. The stoichiometry, biochemical mechanism, optimal physiological conditions, etc., for H2 evolution are being studied.

RESULTS: Mutants have been developed and tested and one was found in which H2 evolution is observed with glucose as substrate. The stoichiometry has been measured.

SUPPORTED BY U.S. Dept. of Energy, Div. of Biomedical & Environmental Research

2.0024,

PILOT PLANT STUDIES FOR PRODUCTION OF SUGARS AND ETHANOL BASED ON THE ENZYMATIC HYDROLYSIS OF CELLULOSE

C.R. Wilke, University of California, Berkeley Campus, Lawrence Berkeley Lab., *Berkeley, California* 94720 (S-189)

This grant will finance a study on enzymatic hydrolysis of cellulosic materials and the fermentation of the resulting sugars to ethanol. The materials to be investigated include: cotton gin trash, wheat straw, barley straw, rice hulls, rice straw, corn stalks, and logging residues. The immediate program will involve a systematic study of the processing characteristics of the various potential raw materials discussed above. Data to be obtained will include chemical composition of the original material and of the products of enzymatic conversion, required pretreatments, and rates of conversion and enzyme consumption. These results will serve as a basis for final design of the hydrolysis pilot plant and for the selection of raw materials to be processed. Two fermentation methods will be investigated: (1) atmospheric pressure continuous fermentation and (2) vacuum fermentation. An engineering analysis of the two methods will be made so that an alcohol pilot plant can be designed to operate with the hydrolysis unit. (ERDA 76-137)

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0025,

FERTILIZER PRODUCTION WITH NITROGEN-FIXING HETEROCYSTOUS BLUE-GREEN ALGAE

W.J. Oswald, University of California, Berkeley Campus, School of Engineering, Dept. of Civil Engin, *Berkeley, California* 94720

The overall objective of this project is to assess the feasibility of fertilizer production by ponds containing nitrogen-fixing heterocystous blue-green algae. These types of algae are unique in their ability to carry out photosynthesis and nitrogen fixation simultaneously. They can be easily harvested because they are filamentous in nature and rapidly grow on simple media, polluted water, or sewage.

The research plan consists of a screening process using small-scale cultures of several strains of heterocystous blue-green algae. Nitrogen fixation, phosphate content and growth will be followed in various media and conditions. Variables to be examined are aeration, biological contaminations, pH and media composition. A few strains will be selected for large-scale experiments, strain improvements, and for studies of the physiology and regulation of nitrogen fixation and metabolism in blue-green algae. Large scale facility algal ponds will also be operated simultaneously with the strain selection and physiological experiments so that development of algal pond management techniques and engineering designs can proceed rapidly and provide feedback to the laboratory work. The algal fertilizer produced will be tested in greenhouses and field experiments with crop plants. A financial analysis of the economic viability of this method of fertilizer production will also be undertaken. This will focus the needs for future research and the developments to optimize yields and integrate algal fertilizer production with algal sewage treatment and algal fuel production.

SUPPORTED BY U.S. National Science Foundation, Div. of Advanced Energy & Resources Research & Technology

2.0026,

IMPACTS OF LARGE-SCALE USE OF METHANOL AND METHANOL-GASOLINE BLENDS AS AUTO FUELS

F. Milanovich, University of California, Central Office, Lawrence Livermore Lab., *P.O. Box 808, Livermore, California* 94550

Review literature and compile bibliography. Identify problem areas requiring investigation and answers, and formulate a recommended R and program. Prepare a report to sponsoring division for its internal use and guidance in establishing a program which addresses problems and provides needed answers.Report to be used as source of information on state-of-the-art and for guidance for the development of an assessment program to determine environmental, health and safety problems and issues associated with the wide scale use of methanol or methanol-gasoline blends in automobiles.Draft report dated July 27, 1977, was prepared by LLL and was submitted to DOE/BER for its review and program use.

SUPPORTED BY U.S. Dept. of Energy, Div. of Biomedical & Environmental Research

2.0027,

UTILIZATION OF ANIMAL, CROP AND PROCESSING RESIDUES

N.B. Akesson, University of California, Davis Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Davis, California* 95616 (CA-D#-AER-2971-H)

OBJECTIVE: Investigate means and processes for obtaining greater utilization of animal, crop and food processing plant wastes by recycling, conversion and energy recovery techniques. Control and reduction of air, water and soil pollution would be a basic consideration.

APPROACH: Laboratory and field studies would be conducted on open field burning of crop residues and pyrolysis and incineration for any recovery; animal and food processing wastes would be examined for recycling to animal feeds; all types of wastes would be studied in soil plots for recovery of nutrients and encouragement of soil bacteria conversion to useable plant nutrients.

PROGRESS: Crop and forest residues - A system was designed, constructed, and tested to air dry chicken manure from cage houses in Southern California. The system functioned exceptionally well producing dry stabilized manure in about 72 hours during summer months without fly production. Field tests on soil incorporation of cannery wastes were complete - results will be published in the coming year concerning rates (4-6 tons/A) and excess salt and nitrogen. Drying rates (3 to 4 days) packing methods (rectangular and big roll bales), on-farm storage costs ($20/ton-rectangular bales: $12/ton big roll bales) and transporation costs for commercial use of rice straw were studied. A feasibility study on the total harvest of rice straw was completed. Publications are being prepared and will report favorable cost comparison between rice straw and coal to fire a steam powered electric generating plant. Residue conversion to energy - Two laboratory-scale downdraft gas producers were constructed and tested. Low BTU producer gas was satisfactorily used as fuel for spark ignition engines. A pilot plant gas producer was designed, constructed and thoroughly instrumented to gasify crop and forest residues. Design gas production rate is 8 to 10 million BTU/hr. Performance will be tested first with walnut shells than other residues during 1977.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, California

2.0028,

ASSESSMENT OF UTILIZING RICE STRAW FOR ON-THE-FARM POWER GENERATION

B. Horsfield, University of California, Davis Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Davis, California* 95616 (1090-16063-002-C)

OBJECTIVE: Obtain a technological and economic assessment of the utilization of rice straw residue from the California Sacramento Valley for on-the-farm generation.

APPROACH: This study will provide an evaluation of the economic feasibility of rice straw for on-the-farm or local agricultural communities being converted to a utilizable energy form, including the cost of collection and transportation; an assessment of the existing and proposed hardware including basic design parameters. Recommendations will be made for research and development efforts to reduce or eliminate environmental, sociological, or institutional constraints; recommendations for or against the concepts of energy recovery from rice straw. If the concept appears promising, the study will include recommendations for equipment development and systems operations.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Beltsville Agricultural Research Center

2.0029,

HYDROCARBONS AND ENERGY FROM PLANTS

R.M. Sachs, University of California, Davis Campus, Agricultural Experiment Station, Dept. of Environmental Horticulture, *Davis, California* 95616 (CA-D#-EHT-3608-H)

OBJECTIVE: determine the feasibility of and develop preliminary information on the technology for economic production of hydrocarbons and related materials for fuel or chemical feedstocks by means of managed farming of Euphorbias, Asclepias and Eucalyptus.

APPROACH: Periodic evaluation of yields of benzene-acetone extractable hydrocarbons as well as total caloric value under two climatic and various cultural conditions. Harvesting and process chemistry methods will also be explored. If yield data and harvesting and processing results are promising, economic analysis of cultural and harvesting costs would be undertaken.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, California

2.0030,

SOIL AS A WASTE TREATMENT SYSTEM

P. Stout, University of California, Davis Campus, Agricultural Experiment Station, Dept. of Soils & Plant Nutrition, *Davis, California* 95616 (CA-D#-SPN-2844-RR)

OBJECTIVE: Determine the effects of waste components on the chemical, physical and biological properties of soils. Characterize soils in relation to their 'waste treatment capabilities' and determine soil parameters of most significance in the retention, fixation and transformation of waste components consistent with meeting quality standards of water and air. Devise guidelines for identifying and inventorying recognized taxonomic soil units most effective for various types of waste management systems.

APPROACH: Beneficial modification of soil physical properties will be evaluated as functions of quantity and quality of treated animal wastes when combined with soil materials. Modulus of rupture and a time-lapse photography to observe the mechanics of soil rupture during seedling emergence will be used. Soils and wastes will be characterized according to regional plan.

PROGRESS: Animal manures (AMs) (poultry, beef, dairy, horse, sheep, swine) and dispersed organic wastes of the field, forests and processing plants (corn stalks, rice straw, rice hulls, tomato waste, wood-chip fiber) have been assayed for intrinsic heat content and ash and compared with oil shale. Heats of combustion ranged from 12.2 (chicken) to 15.5 (dairy) Million Btu's (MBtu) per air-dry ton versus 4.6 MBtu for an oil shale that can yield 30 gallons of oil per ton with 77% ash. The ash of AMs ranged from 33% (chicken) to 21% (dairy). These facts have given rise to concepts of economic exploitation of dispersed organic residues as renewable energy resources; whereby small generators, fueled by organic residues of fields and forests, would feed electrical current directly into established electrical networks. Experiments show that the P and K of the ash is as fully plant available as from fresh, unburned residues. Neutralization with H(2)SO(4) makes the P in ash the equivalent of P in superphosphate fertilizers.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, California

2.0031,

POULTRY PRODUCTION AND ENVIRONMENTAL QUALITY

W.O. Wilson, University of California, Davis Campus, Agricultural Experiment Station, Dept. of Avian Science, *Davis, California* 95616 (CA-D#-AVS-3372-RR)

OBJECTIVE: Determine characteristics of poultry house pollutants and factors influencing their relationship to environmental quality. Determine the effects of poultry house environment and management practices on production efficiency and product quality.

APPROACH: Data from laboratory studies on methods of stabilizing poultry manure to make it less attractive to flies will be collected. Field studies will be made to compare different housing types, e.g., deep pit, flush-out, and open houses, as sources of ammonia, odor and dust. An experimental model of an anaerobic digestor of poultry manure will be operated at different loading levels to determine the amount of methane generated. The residue will be studied as a fertilizer and possibly as an animal feedstuff. Noise inside several houses filled with chickens will be characterized with regard to its frequency range and decibel level.

PROGRESS: Stabilization of poultry droppings was attempted using the following chemicals: sodium silicate (obtained as 40% solution), lime, ferric chloride and alum. About 7.7 gram sodium silicate was needed to form a firm gel from a slurry of 385 gram droppings containing 100 gram dry matter. No flies hatched on this product. A pellet containing 150 gram peat moss and 200 gram chicken manure was tried as potting mixture. The anaerobic digester for poultry manure was modified with a full length horizontal stirrer operated at 1/2 RPM continuously, and with manure loading mechanism. Further studies were continued on the optimum loading rates. The efficiency appears to be optimal at 2.0 to 2.2 kg volatile solids/day/m . The following parameters were determined in several commercial poultry houses during June and July: temperature, humidity, air movement, cooling methods, sound levels, dust loads, gas analysis, light intensities, and cage size and densities.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, California

2.0032,

BIOLOGICAL GENERATION OF METHANE AND HYDROGEN

Unknown, University of California, Los Angeles Campus, Graduate School, *405 Hilgard Ave., Los Angeles, California* 90024

DESCRIPTION: Purpose: Develop alternative sources of fuels. Project objectives: Determine the optical organic materials for methane production. Separate the hydrogen step from the methane step. Develop information on growth kinetics. Breadboard methane process.

ADDENDA: Estimated calendar year funding reported as 1975 $100,000.

SUPPORTED BY Southern California Edison Co.

2.0033,

UTILIZATION OF ALCOHOLS AS ALTERNATE TRANSPORTATION FUELS

R.K. Pefley, University of Santa Clara, School of Engineering, Dept. of Mech Engin, *Santa Clara, California* 95053 (EC-78-C-03-1737)

Alcohols are being studied as alternatives to petroleum fuels for transportation. Dynamometer mounted engines are being characterized with petroleum fuels then modified and comparatively tested with alcohols in terms of performance and emissions. Computerized combustion kinetic studies are being used to guide further engine modifications. Vehicles have now been operated on public streets on neat methanol for seven years. A five-car fleet of vehicles is expected to be operational in the fall of 1978. Comparative smog chamber studies are under way contrasting the photochemical reactive of emissions from gasoline-powered automobiles to alcohol-powered automobiles. Comparative alcohol and jet engine fuel studies are also being conducted.

BIBLIOGRAPHIC REFERENCES: Pefley, et al., Characterization and Research Investigation of Methanol and Methyl Fuels, Final report, EPA Grant No. R803548-01, ME77-1, Aug. 77.

SUPPORTED BY U.S. Dept. of Energy

2.0034,

ECONOMICS OF ANIMAL WASTE MANAGEMENT AND ENVIRONMENTAL QUALITY

C.K. Gee, Colorado State University, Agricultural Experiment Station, *Fort Collins, Colorado* 80523 (NRE-41-302-08-01)

OBJECTIVE: Evaluate the economic impact on livestock farmers, consumers, processors, marketing firms, and taxpayers of proposed and potential guidelines; evaluate alternative animal waste systems; and determine least-cost abatement practices.

APPROACH: The cattle feeding, dairy, hog, and poultry portions of the livestock industry will be studied. First, attention will focus on the economic impact of proposed point source effluent limitation guidelines. Secondly, the economic impact of alternative measures and guidelines relating to the control of nonpoint sources of animal waste will be analyzed. The basic analytical approach will be a series of partial equilibrium analyses employing budgeting and linear programming techniques.

PROGRESS: Over one-fifth of all farms producing hogs in the 15 major hog-producing states were estimated to have runoff problems. The impact of runoff control would fall more heavily on small producers. Farms selling fewer than 100 hogs annually would incur investments of about $61 per hog and additional annual costs of $4.24 per 100 pounds of hogs sold. Farms with output above 1,000 hogs would require $4.00 investment per hogs and $0.26 of additional operating costs per 100 pounds. However, after adjustment to comply with environmental regulations are completed, pork will be little or no more expensive to the consumer. Feedlots of over 2,000 head capacity accounted for 58 percent of all feed cattle marketings in the U.S. in 1973. Fifty-six percent of the feedlot spread manure on land that they operate. The average application rate was 18 tons per acre. The value of gas (fuel) and sludge (fertilizer) from anaerobic production of methane from animal waste is expected to exceed annual costs if the output can be fully used. Michigan feedlots would adjust to pollution abatement controls by modest reductions in beef output.

SUPPORTED BY U.S. Dept. of Agriculture, Economics Statistics & Cooperatives Service, Natural Resource Economics Div.

2.0035,

ENERGY AND FOOD PRODUCTION FROM AGRICULTURAL WASTE PRODUCTS

J.M. Harper, Colorado State University, Agricultural Experiment Station, *Fort Collins, Colorado* 80523 (COL00055)

OBJECTIVE: Evaluate fermentation processes for increased energy and/or food production from agricultural waste materials.

APPROACH: Initial approaches will involve cattle manure as the agricultural waste material. Increase fermentation rate, the manure will be fractionated into a water soluble and insoluble fraction and the soluble fraction fermented. A thorough study of concentration, pH, nutrient levels, temperature and volatile solids will be made on methane production and gas composition as well as single cell food production and quality. Secondly, hydro-oxidation will be used to partially hydrolyze cellulose and lignin in manure prior to fermentation. Process parameters will be studied and optimized. Techniques found beneficial on cattle manure will be tried on other similar agricultural wastes.

PROGRESS: Using a counter-current water washing system, manure has been fractionated into a water soluble and a water insoluble fraction. The water insoluble fraction is primarily cellulosic in nature. This material has been used as the fermentation media for a variety of fungi but particular emphasis has been placed on Tricoderma virde. With the addition of salts, active fermentation results. Extra-cellular cellulose is produced and determinations are being made on its activity and methods for its concentration. The purpose of the aerobic fermentation of the cellulosic fraction is to enhance its true protein content and to produce glucose which will be used as an energy source for the anaerobic fermentation of the water soluble manure fraction. Our studies have shown that the anaerobic fermentation is enhanced by addition of a carbohydrate source. Pretreatment of the cellulosic waste appears critical for rapid fermentation. A high pressure autoclave has been installed and a variety of temperature and oxidational pretreatments will be tried. In addition, peracitic acid, Fentons Reagent and permangenate will also be tested. Controlled hydroxidation looks very promising at this point.

SUPPORTED BY Colorado State Government

2.0036,

ANIMAL WASTE MANAGEMENT SYSTEMS FOR THE 1980'S

S.M. Morrison, Colorado State University, College of Veterinary Medicine & Biomedical Sciences, Dept. of Microbiology, *Fort Collins, Colorado* 80523 (COL00222)

OBJECTIVE: Develop optimal animal manure management systems to meet the evolving environmental and economic requirements and be compatible with the increasing needs of our nation and the world for animal protein; investigate use of by-products of animal manure management systems for energy sources, feed ingredients, plant nutrients for crop production and other potential uses with consideration of the human, animal and plant health factors.

APPROACH: Examine the role of feedlot waste (FLW) particle size on chemically modifying manure for fermentations and explore the dual culture (mold and yeast) fermentations process as a means of

converting cellulosics to carbohydrates for yeast protein growth. The fermentation of fractionated and pretreated manures are used to increase biomass in an energy self-sufficient system to enhance the value of manure for refeeding; Studies to impove the protein recovery from FLW are to be made. Harvesting practices are to be studied to provide greatest retention of valuable manure constituents while minimizing detrimental environmental impacts. The modified manures are to be examined as substrate for optimizing bacterial methane production. Further evaluation of the sodium content in feeds are to be made to reduce runoff salt pollution by better management of feeds. The use of solar radiation transparent coverings over feedlot area to eliminate precipitation, evaporate feedlot moisture and reduce the volume of manure to manage as well as odors is to be examined. Increased environmental temperatures of the animals should also be beneficial.

PROGRESS: Feedlot waste (FLW) pre-treated with H(2)O(2) and FeSO(4) (HPFS) increased susceptibility to enzymatic hydrolysis with Trichoderma viride OM 9414 cellulase. About one-hald the cellulosic components are converted to fermentable carbohydrates. Treatment significantly reduced populations of total aerobic, fecal coliform and streptococcus, and spore-forming anaerobic bacteria. Particle size greatly affected cellulase hydrolysis. Dual fermentation by T. viride and Candida utilis was successfully demonstrated with over 90% of the released FLW sugar being converted to yeast, a high quality protein. Procedures for extraction and recovery of the protein-rich fraction have been developed. Studies with anaerobic digestion of FLW showed 6% wt./vol. to be optimal for mesophilic methane production.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Colorado

2.0037,

CONVERSION OF FEEDLOT WASTE INTO SINGLE CELL PROTEIN ANIMAL FEED

R.P. Tengerdy, Colorado State University, College of Veterinary Medicine & Biomedical Sciences, Dept. of Microbiology, *Fort Collins, Colorado* 80523 (COLV02880)

OBJECTIVE: Convert feedlot waste (FLW) into animal feed and fuel.

APPROACH: This will be accomplished in a two stage microbial fermentation process. Since the cellulose left in FLW after the ruminant digestion process is resistant to microbial degradation in an anaerobic digester, the cellulosic fraction of FLW will be separated, physically or chemically pretreated, and then fermented with Trichoderma viride in an aerobic fermentation. This results in cellulase production and the conversion of cellulose to glucose, and in fungal biomass production. The soluble, nitrogen rich, fraction of FLW will be fermented in an anaerobic digester, using the residual glucose stream from the aerobic process to produce microbial single cell protein and methane. The fermentation will be controlled by the C/N ratio, volatile dry matter, pH, temperature, retention time, and the microbial culture to maximize SCP production. The two feed products will be evaluated in nutritional studies. An engineering design for a pilot plant capable of handling 1500 kg FLW/day will conclude the research.

SUPPORTED BY U.S. Dept. of Agriculture

2.0038,

CONVERSION OF FEEDLOT WASTE INTO SINGLE CELL PROTEIN ANIMAL FEED (US/ USSR PROGRAM IN MICROBIOLOGY)

J.M. Harper, Colorado State University, School of Engineering, Dept. of Agricultural Engineering, *Fort Collins, Colorado* 80523

The objective of this project is the conversion of feedlot waste (FLW) into animal feed and fuel. Since feed is economically more valuable than fuel, the research is aimed toward more feed than fuel production. This will be accomplished in a two stage microbial fermentation process. Since the cellulose left in FLW after the reminant digestion process is resistant to microbial degradation in an anaerobic digester, the cellulosic fraction of FLW will be separated, physically or chemically pretreated, and then fermented with Trichoderma viride in an aerobic fermentation. This results in cellulase production and thus conversion of cellulose to glucose, and in fungal biomass production. The soluble, nitrogen rich, fraction of FLW will be fermented in an anaerobic digester, using the residual glucose stream from the aerobic process to produce microbial single cell protein and methane. The fermentation will be controlled by the C/N ratio, volatile dry matter, pH, temperature, retention time, and the microbial culture to maximize SCP production. The two feed products will be evaluated in nutritional studies. An engineering design for a pilot plant capable of handling 1500 kg FLW/day will conclude the research. This research will be conducted in cooperation with Russian researchers to be designated.

SUPPORTED BY U.S. National Science Foundation, Div. of Engineering

2.0039,

ENERGY PRODUCTION FROM AGRICULTURE PRODUCTS

J.M. Harper, Colorado State University, School of Engineering, Dept. of Agricultural Engineering, *Fort Collins, Colorado* 80523

Description: The initial approaches will involve cattle manure as the agricultural waste material. To increase fermentation rate, the manure will be fractionated into a water soluble and insoluble fraction, and the soluble fraction fermented. A thorough study of concentration, pH, nutrient levels, temperature and volatile solids will be made on methane production and quality. Secondly, hydro-oxidation will be used to partially hydrolyze cellulose and lignin in manure prior to fermentation. Process parameters will be studied and optimized. Techniques found beneficial on cattle manure will be tried on other similar agricultural wastes.

Addenda: Estimated calendar year funding reported as 1974 $5,000, 1975 $7,000.

SUPPORTED BY Colorado State University

2.0040,

COMPETITION FOR RURAL RESOURCES

M. Skold, Colorado State University, U.S. Dept. of Agriculture Natural Resource Economics Div., *Fort Collins, Colorado* 80523 (NRE-43-322-08-01)

OBJECTIVE: Develop functional relationships for the supply of land to agriculture and among competing uses, relating land availability to commodity prices, commodity policies, resource policies, non-agricultural competing uses and other significant variables. Relate agricultural land availability to agricultural capacity and develop linkages between policy variables and the amount of land used and agricultural capacity.

APPROACH: Develop a system to account for land use changes over time as between agricultural uses, abandonment, reclamation, by irrigation or drainage, recreation, forestry, urbanization and surface mining. Use economic theory, models and statistical techniques to estimate functions relating land use for various purposes to explanatory variables. Using a regional definition system consistent with other projects and progress areas of the Division and of the Commodity Economic Division, integrate land supply among competing uses by region. In cooperation with other Divisions, integrate land supply estimates with estimates of input supplies, yield projections and other measures of productivity to capacity of agriculture.

PROGRESS: The year provided evaluations of the nature and extent of competition for rural resources from several sources. The actual withdrawal of land and water from agricultural production for surface mining will have rather minor consequences to agricultural output potentials. Preliminary analyses reveal the biomass energy could be competitive with returns from non-irrigated agricultural production at cost of about $3 per 10 BTU's. Without significantly increased costs of alternative energy sources, land and water use for biomass production are not economic at the present. Should biomass production become feasible, sizable amounts of land would be required. Research on the effects of urbanization and population growth on agriculture across the U.S. has revealed that each one percent increase in population density in urban areas is associated with a 1.05% increase in farmland values. Examination of the factors associated with groundwater irrigation development in the Central and Southern Plains have not reached any conclusions. The effects of energy prices and availabilities on these agricultural production systems are significant, however.

SUPPORTED BY U.S. Dept. of Agriculture, Economics Statistics & Cooperatives Service, Natural Resource Economics Div.

2.0041,

FEEDLOT ENERGY RECLAMATION DEMONSTRATION

W.B. Coe, United Technologies Corp., Hamilton Standard Division, *Bradley Field Rd., Windsor Locks, Connecticut* 06096 (E(11-1)-2615)

The objective of this program is to demonstrate to the feedlot industry a system which is the source of fuel gas to achieve feedlot energy self-sufficiency. Using cattle manure as feedstock, the process generates methane that can be used as fuel and carbon dioxide that can be utilized as refrigerant, and produces a high protein "residual" which is suitable as an animal food supplement or fertilizer. A preliminary design of a full-scale system for Monfort, along with an economic evaluaton of the commercial viability of the system will result from the contract. The design support testing will utilize the Hamilton Standard Mobile Cattle Waste Processing System trailer at a Monfort of Colorado feedlot. This test program will be "site specific" confirming the performance and stability of the anaerobic fermentation process by operating under field conditions typical of those at this operational feedlot, with a system utilizing commercially available equipment and processing significant quantities of beef cattle waste. This testing will also confirm the yield and quality of output fuel gas and carbon dioxide generated by the process. In conjunction with the test program, an economic analysis will be conducted of the CWCS parameters relative to Monfort's requirements. All feedlot energy consumption, utilization rates and dry ice (CO-2) requirements will be identified. Cost histories of Monfort's expenditure in these areas will be prepared. Subsystem trade studies will be conducted and analyzed to determine the optimum size of the full-scale system required to meet Monfort's present and projected energy needs. Finally, an economic analysis will be generated that will include annual system operating costs, predicted value and CO-2 produced, quantity and value of residual produced, and the net annual value of the system. (ERDA 76-137)

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0042,

PILOT PLANT PRODUCTION OF METHANE BY DIGESTION OF FEEDLOT WASTE

W.B. Coe, United Technologies Corp., Hamilton Standard Division, *Bradley Field Rd., Windsor Locks, Connecticut* 06096 (3090-20401-001-C1)

OBJECTIVE: Confirm performance of anaerobic digestion of feedlot waste for production of fuel gas and establish the nutritional value of effluent solids.

APPROACH: Design and construct a pilot plant at U.S. Meat Animal Research Center to process 350 pounds per day of beef cattle waste. Monitor operation to determine process stability, equipment performance, and yield of methane gas. Incorporate effluent solids from digestion of the waste into experimental diets and evaluate with sheep and cattle to determine acceptability and nutritional value. Ascertain feasibility of the process as a pollution abatement and energy conservation system for feedlots.

PROGRESS: A pilot plant at USMARC for the anaerobic digestion of animal wastes was designed, constructed, and initially operated under contract by Hamilton Standard Division of United Technologies. The facility was designed to operate over a wide range of conditions and with varied waste materials. The 1250-gallon digester is designed for standard operation at 100 pounds d.b. input waste per day. The pilot plant became operational in November 1976 and is functioning in a stable mode at a feed rate of 0.25 pounds/cu. ft., 11-datime, 52 degrees C., with gas yield of 8 cu. ft./pound v.s. introduced (14 cu. ft./pound v.s. destroyed). The contractor has fulfilled its obligations and ARS research with the facility will be done under CRIS Work Unit 3415-20400-004; CRIS Work Unit 3090-20401-001-C will be terminated.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Northern Regional Research Center

2.0043,

MEASUREMENT AND ANALYSIS OF SOLAR RADIATION IN FOREST STANDS - A NEW APPROACH

K.L. Reed, Yale University, School of Forestry & Environmental Studies, *205 Prospect St., New Haven, Connecticut* 06511

This project will characterize the vertical distribution of solar radiation in forest stands. The experimental

approach consists of reversing the classical source/sensor relationship by placing radiation sources at different vertical levels within forest stands and assaying the radiation transmitted through the above lying canopies. The radiation emitted from these stands is then measured using a sensitive light detector carried on an aircraft. Data produced in this manner are independent of ambient light conditions and, therefore, reflect only the influence of forest structure and foliar biomass upon radiation transmission. By characterizing the radiation climate in forest stands and simultaneously correlating this to measured structural features and foliar biomass distribution, a method can be developed to accurately estimate insolation in forest stands based upon stand structure and measurements of incident direct and diffuse radiation.

SUPPORTED BY U.S. National Science Foundation, Div. of Atmospheric Sciences

2.0044,

SINGLE CELL PROTEIN BY BIOCONVERSION OF WASTE MATERIALS

F.J. Hicks, Ebon Research Systems, *1542 9th St. N.W., Washington, District of Columbia* 20001 (68-03-2395)

The prime objective of this study is to perform an intensive review of the techniques available to convert waste materials to single cell protein or other high protein feed/food supplement. The review will include comparisons of these processes with the state-of-the-art of SCP production from other substrates, and with food production through traditional methods (farming and fishing). Comparisons will be made between methods in terms of technology, economics, energy requirements, and sociological barriers impeding acceptance of novel protein sources. Additionally, comparisions will be made between food production from wastes and energy production. The report will attempt to cover as wide and as comprehensive a spectrum as possible while remaining comprehensible to the non-scientist.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development

2.0045,

MARKET POTENTIALS FOR U.S. FARM PRODUCTS IN DOMESTIC AND FOREIGN MARKETS

P.B. Dwoskin, U.S. Dept. of Agriculture, Economics Statistics & Cooperatives Service, National Economic Analysis Div., *14th & Independence Ave. S.W., Washington, District of Columbia* 20250 (NEA-12-108-11-00)

OBJECTIVE: Determine foreign market needs and requirements for food and fiber products to identify U.S. market expansion opportunities. Evaluate market penetration of new or modified highly processed foods and their impacts on marketing and food cost, along with the factors associated with product successes or failures. Assess the size and characteristics of industrial markets and the techno-economic requirements of industrial and uses for agricultural products and byproducts.

APPROACH: A general analytical approach will be employed, utilizing data generated by audit and survey techniques to examine foreign market requirements and impacts of new food forms on food cost. On-site surveys, economic-engineering techniques including cost-benefit analyses will be used in analyzing the feasibility of converting agricultural raw materials into fuel, fertilizer, etc.

PROGRESS: Research on the impact of convenience foods on food costs continues. The collection of price data is completed and the ARS has provided comparative data on yield, time preparation, and energy expenditures which will enable specific cost comparisons between convenience foods, and their home-prepared counterparts. Warehouse sales data from 6 retail chains representing 1200 stores are being analyzed for the relative importance of convenience foods to total food purchases. Two studies dealing with new export potentials for U.S. processed products were completed. One study of U.S. fast food industry indicates large foreign expansions plans and an export potential for U.S. products of $800 million by 1979. A study of Japan's western style fast food industry also indicates substantial markets for U.S. products in the next 3 to 5 years. New Hide processing studies have been completed which show substantial benefits from adoption of new technologies to reduce pollution. Another study initiated in FY 1975 concerns the economies in industrial applications of using lubricants made from agriculture processing wastes in lieu of crude petroleum based lubricants. Literature search and planning for study has been completed. Findings of an assessment of the economic feasibility of anaerobic digestion to convert agriculture wastes to fuel, feed and fertilizer indicate that this technology has good potentials as an energy source and for pollution abatement.

SUPPORTED BY U.S. Dept. of Agriculture, Economics Statistics & Cooperatives Service, National Economic Analysis Div.

2.0046,

ECONOMICS OF ANIMAL WASTE MANAGEMENT AND ENVIRONMENTAL QUALITY

J. Schaub, U.S. Dept. of Agriculture, Economics Statistics & Cooperatives Service, Natural Resource Economics Div., *14th & Independence Ave. S.W., Washington, District of Columbia* 20250 (NRE-41-302-11-00)

OBJECTIVE: Evaluate the economic impact on livestock farmers, consumers, processors, marketing firms, and taxpayers of proposed and potential guidelines; evaluate alternative animal waste systems; and determine least-cost abatement practices.

APPROACH: The cattle feeding, dairy, hog, and poultry portions of the livestock industry will be studied. First, attention will focus on the economic impact of proposed point source effluent limitation guidelines. Secondly, the economic impact of alternative measures and guidelines relating to the control of nonpoint sources of animal waste will be analyzed. The basic analytical approach will be a series of partial equilibrium analyses employing budgeting and linear programming techniques.

PROGRESS: Over one-fifth of all farms producing hogs in the 15 major hog-producing states were estimated to have runoff problems. The impact of runoff control would fall more heavily on small producers. Farms selling fewer than 100 hogs annually would incur investments of about $61 per hog and additional annual costs of $4.24 per 100 pounds of hogs sold. Farms with output above 1,000 hogs would require $4.00 investment per hogs and $0.26 of additional operating costs per 100 pounds. However, after adjustments to comply with environmental regulations are completed, pork will be little or no more expensive to the consumer. Feedlots of over 2,000 head capacity accounted for 58 percent of all feed cattle marketings in the U.S. in 1973. Fifty-six percent of the feedlots spread manure on land that they operate. The average application rate was 18 tons per acre. The value of gas (fuel) and sludge (fertilizer) from anaerobic production of methane from animal waste is expected to exceed annual costs if the output can be fully used. Michigan feedlots would adjust to pollution abatement controls by modest reductions in beef output.

SUPPORTED BY U.S. Dept. of Agriculture, Economics Statistics & Cooperatives Service, Natural Resource Economics Div.

2.0047,

DIRECT COMBUSTION - FOREST ENERGY PROGRAM

J.I. Zerbe, U.S. Dept. of Agriculture, Forest Service, *14th & Independence Ave. S.W., Washington, District of Columbia* 20250 (E(49-26)-1045)

The objectives of this project are evaluation of the fuel potential of forest residues and analysis of systems for collecting and processing these residues. Pulp and paper mills, consumers of about 85 percent of all energy for forest industries, are receiving prime consideration for switching from fossil fuels to combustion of wood residues. Factors in this study are: Overall regional variations of distribution of forest land. Residue availability and benefits of removal for forest management, insect control, and fire prevention. Selection of sites for residue energy centers. Development of specific data for each site on availability, costs of collection, and transportation of residues to the center. Assessment of impact of residues on each center's energy needs.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0048,

BOMB CALORIMETRY OF REFUSE AND REFUSE-DERIVED-FUELS

S. Abramowitz, U.S. Dept. of Commerce, National Bureau of Standards, *Washington, District of Columbia* 20228

PROJECT OBJECTIVE: To develop test procedures for the determination of calor. Values of refuse and refuse-derived-fuels (RDF). These data are to be used to assess the utility of these energy sources in process heat and power generation.

PROJECT APPROACH: Establish methods for preparing and characterizing samples of refuse and RDF suitable for calorimetric studies. Conduct calorimetric tests of samples from various sources. Investigate effects of sample preparation, size, composition (e.g., elemental, ash and moisture) on the effective heating values. Design appropriate calorimeters.

PRIOR YEAR ACCOMPLISHMENTS: Ouantitative characterization of combustion residues by x-ray fluorescence. Sulfur, chlorine and carbon analysis of products. Construction of large (25G) bomb calorimeter.

SUPPORTED BY U.S. Dept. of Commerce, National Bureau of Standards

2.0049,

FIRE SAFETY ASPECTS OF WOOD AS A FUEL

J.H. Winger, U.S. Dept. of Commerce, National Bureau of Standards, *Washington, District of Columbia* 20228

PROJECT OBJECTIVE: Develop test methods, standards, and recommended practices as necessary to assure that increased use on wood as a fuel does not create unreasonable fire risks.

PROJECT APPROACH: Review the available accident data. Survey the literature and various codes and standards. Conduct experiment work program as indicated in the above review and survey. Make appropriate recommendations.

SUPPORTED BY U.S. Dept. of Commerce, National Bureau of Standards

2.0050,

CAPTURING THE SUN THROUGH BIOCONVERSION

P. Schauffler, U.S. Executive Office of the President, Council on Environmental Quality, *722 Jackson Pl. N.W., Washington, District of Columbia* 20006 (C624B-7201)

OBJECTIVES - To provide coordination for a conference on bioconversion, with a review of how biomass is converted into natural gas, alcohols, oils, solid fuels, animal feeds, human foods, fertilizers, and industrial chemicals. Production, collection, and conversion costs, both economic and environmental, and how bioconversion fits into the world's search for supplements to fossil and nuclear fuels will be considered.

APPROACHES - Organization of a conference to be held in Washington, D.C. March 10-12, 1976.

PROGRESS - Conference was held and proceedings have been published.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Municipal Environmental Research Lab.

2.0051,

BIOMASS PRODUCTION AND COMPOSITION OF SUGARCANE

G.J. Gascho, Agricultural Research & Education Center, *Belle Glade, Florida* 33430 (FLA-EV-01862)

OBJECTIVE: Gather sugarcane biomass production and plant composition data for use in energy farming feasibility studies. Specific objectives are: Determine the biomass production, plant composition, nutrient uptake, and leaf area index with time for plants grown at 0.5 and 1.5 m spacings; relate climatic factors such as rainfall, solar radiation, and temperature to biomass and plant composition; and estimate the water requirements of sugarcane grown at the two spacings.

APPROACH: Sugarcane will be planted at 0.5 and 1.5 m row spacings. Monthly harvests will determine biomass for the row spacings. Complete nutrient non-nutrient analyses of tops, stalks and leaves will allow calculations of nutrient uptake and plant composition. Leaf area index and weather data will be regressed against yield parameters. A primary water budget will be estimated by water table, hydraulic conductivity and moisture content measurements.

SUPPORTED BY Florida State Government

2.0052,

SUGARCANE PRODUCTION RESIDUES, AND ASSESSMENT FOR CONVERSION TO UTILIZABLE ENERGY FORMS

R.A. Nordstedt, State University System of Florida, University of Florida, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Gainesville, Florida* 32601 (1090-16065-004-C)

OBJECTIVE: Obtain a technological and economic assessment of methods for the conversion of sugarcane production residues to utilizable energy forms.

APPROACH: A library and field study will be performed to obtain data to evaluate the full technologic and economic feasibility of converting sugarcane production residues into utilizable energy forms. Quantities and spacing distributions of residues will be evaluated. The technological and economic feasibility of various conversion processes will be undertaken. Technologic gaps will be identified and environmental, sociological and operational problems will be evaluated.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Beltsville Agricultural Research Center

2.0053,

ANIMAL WASTE TREATMENT AND RECYCLING SYSTEMS

R.A. Nordstedt, State University System of Florida, University of Florida, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Gainesville, Florida* 32601 (FLA-AG-01649)

OBJECTIVE: Monitor harmful or nuisance residual components and study methods of control. Study performance of treatment systems, and study effect of application rate on soil-crop system.

APPROACH: Coordinated laboratory, pilot scale and field studies will be initiated to identify potential sources of groundwater pollution from animal producting units, including anaerobic and aerobic lagoons, identify methods of controlling or minimizing groundwater pollution. Evaluate physical, chemical and biological factors affecting anaerobic and aeribic decomposition of animal wastes. Evaluate the effects of effluents from animal waste handling systems on the soil-plant-groundwater system, and formulate criteria or guidelines for the design and operation of animal waste management systems.

PROGRESS: Modeling of anaerobic processes continued by refining the model originally developed and expanding the types of wastes to include food waste. Odor modeling was completed. Two pilot scale anaerobic digestion systems utilizing solar heat were designed and construction initiated. Methane recovery rates from anaerobic lagoons using floating collectors were not as high as anticipated. This could have been due to leaks in the membrane. More work needs to be done on the type of membrane used. Methane content of the biogas was 68 percent for swine and 63 percent for a dairy lagoon. The overland flow system for disposal of polluted runoff has been monitored for 18 months and performed very satisfactorily.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Florida

2.0054,

ANIMAL WASTE TREATMENT AND RECYCLING SYSTEMS

P.H. Smith, State University System of Florida, University of Florida, Agricultural Experiment Station, Dept. of Microbiology, *Gainesville, Florida* 32601 (FLA-BC-01649)

OBJECTIVE: Study the effect of alternate treatments of animal wastes on odor abatement. Study the performance of various treatment systems on animal wastes and wastewater, prior to disposal.

APPROACH: Dairy wastewater will be passed through an anaerobic filter with a retention time of less than 24 hours. Odor production produced by fermentation of the effluent will be compared to odor production produced by fermentation of the influent. Vertical and horizontal stratification of biological activity in a dairy waste lagoon will be quantitated. The mixing procedure producing maxium lagoon samples obtained by mixing material from locations having different activities.

PROGRESS: Methanogenic enrichments were examined to determine if hydrogen is or is not an intermediate in the production of methane from acetate, propionate and butyrate. Large volumes of 100% CO(2) were bubbled through enrichments fed either acetate, propionate and butyrate. The recovered gas was analyzed for hydrogen and methane. Large amounts of hydrogen were produced from propionate and butyrate but not from acetate. Propionate and butyrate enrichments utilized externally provided hydrogen in large amounts, with no lag. Similar results were not observed with acetate enrichments. That data shows that propionate and butyrate are metabolized by a non-methanogenic bacterial population which produces large amounts of hydrogen. No evidence was obtained indicating hydrogen production from acetate.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Florida

2.0055,

ENERGY ANALYSIS OF MODELS OF THE UNITED STATES

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This is a renewal proposal to continue developing, evaluating and simulating an analysis model of the United States including energy sources, sectors of the economy and environmental interaction. Included in this year's objectives are transportation alternatives, potentials of a wood economy, air conditioning, shaft mined coal, health care, air pollution, energy analysis of disasters of earthquake, hurricane, tornado, etc., the simulation of a state energy model (Florida), the calculation of energy quality of natural gas, peat, wood soil, land and other main components of the U.S. systems.

The methods we use differ in several ways from those used by others. A special effort will be made to review reports and publications on net energy and energy analysis by other groups making energy analysis diagrams with their data for comparison, locating and showing what differences there are in what is included and how these differences make conclusions different.

Energy quality evaluations will be used to make maps of U.S. energy expressed in units of equality and from these a map of combined energy potentials for the country. Eight questions of energy theory will be explored.

RESULTS: A preliminary aggregated model of the world energy is used to drive a preliminary aggregated model of the U.S. and its economy. Net energy analyses have been made of many of the alternative primary energy sources and secondary sources and from the yield ratios and investment ratios suggestions as to the best policy for the U.S. energy have been made and presented to Congress.

SUPPORTED BY U.S. Dept. of Energy, Div. of Biomedical & Environmental Research

2.0056,

A SURVEY OF HYDROGEN PRODUCING PHOTOSYNTHETIC ORGANISMS IN TROPICAL AND SUBTROPICAL MARINE ENVIRONMENTS

A. Mitsui, University of Miami, Graduate School, Dept. of Biology & Living Resources, *Miami, Florida* 33124

This award is a continuation of NSF grant AER 75-11171 whose objective is to survey tropical and subtropical marine environments for hydrogen producing microorganisms. In tropical and subtropical marine environments there are many species of blue-green algae and photosynthetic (sulfur and non-sulfur) bacteria that are capable of producing the chemical, hydrogen gas, from renewable resources. These species and other algal species will be collected, isolated and their hydrogen producing capability will be examined. Subsequently, selected species will be subjected to a series of experiments aimed at evaluating the chemical and physical conditions which yield maximum hydrogen gas production efficiency (conversion efficiency and mass culture growth). The ultimate goal of this research is to lay the foundation for the design of an economically feasible hydrogen-producing system using sea water or other available organic and inorganic compounds as hydrogen donors.

SUPPORTED BY U.S. National Science Foundation, Div. of Advanced Energy & Resources Research & Technology

2.0057,

CHARACTERIZATION OF METHANOL/GASOLINE BLENDS AS AUTOMOTIVE FUELS

Unknown, University of Miami, Graduate School, *Miami, Florida* 33124

Basic investigation of the performance of spark ignition internal combustion engines on alcohol/gasoline blends including performance, emissions and induction/combustion relationships.

SUPPORTED BY U.S. Dept. of Energy, Div. of Transportation Energy Conservation

2.0058,

UTILIZATION AND/OR STABILIZATION OF PYROLYTIC OIL FROM PYROLYSIS OF AGRICULTURAL, MUNICIPAL AND OTHER WASTES

J.A. Knight, Georgia Inst. of Technology, Georgia Technical Research Inst., Resource Utilization Lab, *225 North Ave. N.W., Atlanta, Georgia* 30332 (C624A-7034)

The broad objective of this program is to maximize the value of pyrolytic oils obtained by pyrolysis of agricultural, municipal, forestry and other wastes so that maximum resource recovery and economical utilization can be realized from these materials. In order to accomplish this objective, an extensive search and development program is proposed which will develop a data base for evaluation of the oils for uses other than as a fuel. Pyrolytic oils have potential as source of chemicals, as a chemical feedstock, and for specialty uses for specific fractions obtained from the oils.

This program was initiated June 21, 1976, and to date, the technical literature has been surveyed; a variety of distillation experiments have been carried out with pyrolytic oil produced from a continuous large scale pyrolysis operation; and a large number of both physical and chemical techniques and methods have been utilized in characterizing the oil and oil fractions. Particular attention has been given to liquid and gas chromatography as techniques for 'fingerprinting' the oil samples.

During the next project period, the major emphasis of the research will be to continue the investigation of processing methods for pyrolytic oil. Both physical and chemical methods will be investigated and these include extraction, column chromatography, hydrogenation and thermal cracking. Pyrolytic oil will be produced with a 6 inch tube furnace under controlled conditions for use on the program. Concurrent with this effort, the oil products will be characterized by both chemical and physical analytical methods. Liquid and gas chromatography will be used extensively as analytical techniques. The current literature will be searched for technical information that is relevant to this program and for addition to our literature base.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Municipal Environmental Research Lab.

2.0059,

MATERIALS, EQUIPMENT, AND METHODS TO OVERCOME ENVIRONMENTAL POLLUTION BY PEANUT PROCESSING PLANTS

J.D. Woodward, U.S. Dept. of Agriculture, Agricultural Research Service, National Peanut Research Lab., *P.O. Box 110, Dawson, Georgia* 31742 (7704-15700-004)

OBJECTIVE: Develop methods to reduce or eliminate particulate emissions and noise from peanut processing operations and determine most favorable method of peanut hull disposal.

APPROACH: Conduct tests in pilot-scale shelling plant to evaluate the effectiveness of dampening materials, enclosures mufflers, barricades, and modifications of processes in reduction of noise levels of peanut processing equipment. Evaluate various alternative methods of hull disposal. Develop modifications to existing equipment and processes and develop new equipment to reduce particulate emissions from peanut handling and processing.

PROGRESS: Measurements made in the work areas around vane-axial fan units used for drying peanuts revealed values of sound pressure level (SPL) of up to 100 dBA, which restricts exposure of workers to 2 hours under occupational safety laws and creates offensive noise levels for surrounding residents. Mufflers were fabricated and installed on fan, and fan housing was redesigned and modified. Measurements at 10 ft on single fan unit showed reduction from 92.0 dBA average to 82.1, 78.6, and 78.5 dBA with muffler on inlet, mufflers on inlet and exhaust, and with redesigned fan housing, respectively. With

absorptive insert in inlet of muffler, values were 83.4, 74.7, and 73.9 dBA, respectively. Mufflers cost less than $200 and did not significantly affect fan performance. Special treatment of gravity separator in shelling plant reduced average SPL from 90 to 83 dBA. Economic analysis of energy recovery from burning peanut hulls indicated that the large capital outlay for special boiler and other equipment can be justified where onsite usage of fuel for drying peanuts, space heating, solvent extraction, and other processing is large, and where some outlay is already required to dispose of hulls.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Georgia - South Carolina Area

2.0060,

INVESTIGATIONS ON THE UTILIZATION OF PEANUT HULLS IN FEED AND NON-FEED PRODUCTS

D. Burdick, U.S. Dept. of Agriculture, R.B. Russell Agricultural Research Center, *P.O. Box 5677, Athens, Georgia* 30604 (7902-20520-003)

OBJECTIVE: Evaluate peanut hulls and other cellulosic wastes as well as wax substitutes and wax extenders for use in manufacturing artificial fireplace logs. Determine the efficacy of peanut hulls as carrier for liquid supplements.

APPROACH: Various cellulosic wastes will be evaluated alone and in combination with peanut hulls for combustibility and other properties related to development of quality fireplace logs. Various waxes and combinations of waxes and tall oil pitch, low mol. wt. polyethylene waxes, binders, etc. also will be evaluated to determine their feasibility in log manufacture. The absorption by peanut hulls of liquid supplements will be determined as well as their suitability for feeding to dairy cows.

PROGRESS: Incooperative work with a Georgia mushroom grower, peanut hulls were used successfully in a mushroom growing medium. Substitutes for horse manure, that is difficult to obtain in large quantities on a year round basis, the hulls produced a comparable yield of mushrooms. The local availability of hulls compared to the 150 mile shipping distance for manure resulted in a significant reduction of medium cost. A pet litter made from pelleted peanut hulls scented with 1% orange oil was favorable rated by 5 pet owners in comparison to commercial products they have used. The raw material cost of the hull litter appears to be considerably below costs for the currently marketed products. Test of peanut hulls as a substitute for sphagum moss in starter cubes for seedling growth indicated that hulls contained a germination inhibitor that may make them unsuitable for this application without heat treatment.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Athens Georgia Area

2.0061,

ANIMAL WASTE TREATMENT AND RECYCLING SYSTEMS

R.E. Smith, University of Georgia, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Athens, Georgia* 30602 (GEO00565)

OBJECTIVE: Monitor harmful or nuisance residual components and study methods of control; study performance of treatment systems.

APPROACH: Operating anaerobic lagoons will be used to study special problem areas. These include lagoon management, seepage effluent renovation, water reuse and land disposal of effluents.

PROGRESS: In the best management practice for the operation of anaerobic waste lagoons the influent wastewater (plus rainfall entering) is balanced with evaporation and seepage. Such systems have operated successfully for many years. Tests are presently being conducted to operate a similar system where volatile acid production is promoted to reach a concentration sufficient to suppress methane production. Wastewater is pumped from the system through a methane generator with the effluent returned to the acid storage system. While the system continues to function, there has been a disappointing level of volatile acid concentration in the acid storage unit. The swine waste lagoon monitored in this project continues to function well without effluent.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Georgia

2.0062,

HARDWOOD SHORT ROTATION CROPPING

K.L. Steinbeck, University of Georgia, Agricultural Experiment Station, Mcintire Stennis Program, *Athens, Georgia* 30602 (GEO-0025-MS-E)

OBJECTIVE: Continue researching the yields of above- and below-ground biomass of selected hardwoods grown convarious sites at different spacings and coppice cycles under an intensive system of short-rotation management. Study some of the physiological parameters of carbohydrate production, mineral nutrition and reserve food accumulation in coppiced root systems and the mobilization of this reserve into new sprout growth.

APPROACH: Replicated, randomized block designs. Regression and covariance analyses for some growth, and yield studies. Soil and plant tissue analysis will generally include gravimetric and chemical analyses. Height, diameter, weight, photosynthetic and transpirational measurements in field and laboratory. Chemical and physical analysis in the laboratory.

PROGRESS: The longevity and growth patterns of root systems as affected by various rotation lengths are important to the short rotation coppice system. Therefore we excavated root systems of American sycamore planted in 1967 and coppiced systematically since 1969 on one-, two-, and four-year rotations. The root systems were excavated in the summer of 1976 and their dry weights determined. The data are being analyzed.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Georgia

2.0063,

RESOURCE RECOVERY FROM LIVESTOCK WASTES

G.L. Newton, University of Georgia, Georgia Coastal Plain Experiment Station, Dept. of Animal Science, *Tifton, Georgia* 31794 (GEO00271)

OBJECTIVE: Determine if deep-pit stored manure can be used for methane production and the feeding value of digester sludge. Develop means of reducing the nitrogen loss from oxidation ditches. Develop ways of utilizing fibrous materials removed from the stream of a flush waste removal system. Determine if certain algae can be used effectively to produce a usable product from waste waters. Incorporate procedures for resource recovery into systems and evaluate the practicality.

APPROACH: Waste from beef, dairy and swine research units will be available for research on recovery of livestock waste material. Both laboratory and larger scale research studies will be initiated to evaluate the component parts of the waste material for feed, fertilizer and gas production. At the same time, environmental pollution will be monitored.

PROGRESS: Six pastures (0.81 ha each) with established sods of either Coastal bermudagrass (3 pastures) or Pensacola bahiagrass (3 pastures) received three fertilizer treatments. The treatments, applied to one pasture of either grass, were 84 kg N per ha from commercial fertilizer in March and again in June (CF), 84 kg N per ha from liquid manure in March and 84 kg N per ha from commercial fertilizer in June (MCF) and 168 kg N per ha from liquid manure in Manure (M). The manure used was waste from deep pits located beneath a totally slotted floor beef cattle feedlot. Five steers (avg wt 183 kg) were allotted to each pasture in April. These steers were weighed at 28-day intervals during the 168-day grazing trial. The animals were fenced out of an area (9.3 m) in each pasture which was clipped periodically to estimate yield and provide samples for chemical analysis. Pastures receiving treatments MCF; and M tended to produce greater spring growth and greater (P less than .05) steer gains for the first 28-day period. Pasture dry matter yields and steer gains were 13.17 MT/ha and 534 kg/ha, 12.01 MT/ha and 607 kg/ha and 12.40 MT/ha and 575 kg/ha for the CF, MCF and M treatments, respectively. When N recovered in forage is examined in relation to N applied, it was observed that Coastal bermudagrass utilized manure N approximately 85% as effectively as Pensacola bahiagrass.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Georgia

2.0064,

BIOMASS FROM SHORT-ROTATION FOREST TREES

K.L. Steinbeck, University of Georgia, School of Forest Resources, *Athens, Georgia* 30601 (EG-77-S-09-1015)

Design experiments to evaluate the biomass production of sycamore, sweetgum, and European black alder in two 50 acre plantations, one each in the Piedmont and Coastal Plain of Georgia. Fertilization and irrigation responses will be tested along with monitoring tree growth and soil nutrient status. Establish direct energy input-output balance based on biomass yields. Develop cloning techniques for screening and testing superior phenotypes under laboratory and field conditions; following testing, plus genotypes will be identified for future production stock. Trees are to be initially harvested at 3 years then coppiced at 3 to 6 year intervals, and above ground biomass (excluding foliage) yield determined. Foliage will be recycled each year.

SUPPORTED BY U.S. Dept. of Energy

2.0065,

ENERGY FROM ALGAE OF BIOCONVERSION AND SOLID WASTE

L. Raymond, State Natural Energy Inst., *Honolulu, Hawaii*

This is the first phase of a long-term project designed to transform solar energy into stored energy - liquid and gaseous hydrocarbons. Algae, initially the marine diatom Skeletonema custatum, will be cultivated in a recirculating through 3 feet wide and 200 feet long. The culture medium will be filtered seawater with various experimental enrichments such as the effluent from a sewage treatment plant. Unlike most such experimental programs, which investigate the potential of algae as a source of food (and in particular, protein) this project is aimed at the maximum yield of lipids. While land plants have an overall photosynthetic efficiency in the range of 0.7 percent to about two percent, the comparable figure for algae under local conditions is about twelve percent.

Thus algae appear to have excellent potential for a biomass energy conversion process, at least in low, coastal areas. The BTU yield of this experiment is projected to reach or exceed 620 equivalent barrels of oil per acre per year.

SUPPORTED BY Hawaii State Government

2.0066,

STUDIES IN METHANOGENESIS

C.C. Brooks, University of Hawaii System, Manoa Campus, Agricultural Experiment Station, Dept. of Animal Science, *Gilmore Hall, Room 102, Honolulu, Hawaii* 96822 (HAW00240)

OBJECTIVE: Develop, perfect and biologically define an animal waste recycling system(s) for Hawaii which would not only help solve the animal waste disposal problem, but produce some economically valuable by-products (methane, sludge fertilizer and possibly a high protein feed).

APPROACH: A two-phase experimental approach will be utilized. The first will involve small-scale controlled labortory digester experiments to find and define an optimum set of range of conditions needed for maximum methane production. The second phase will involve a pilot plant designed to provide maximum research versatility, thus allowing for comparison of batch vs. continuous fermentation systems, comparison of single vs. series digester systems.

PROGRESS: A trial is being conducted to determine and evaluate the chemical composition of feedlot manure during a six-month fattening period. The manure sampled during the first month has been high in crude protein, 14-20% on a D.M.B. In vitro digestibility studies are also being conducted on the manure. Fifty gallon anaerobic digesters are being constructed to be used in a trial to test the effectiveness of different types of solar heaters to maintain proper digester temperature. Small-scale (4 liter) laboratory digesters are being used as models to test for effectiveness of stirring and effect of temperature and total solids on gas production.

SUPPORTED BY Hawaii State Government

2.0067,

STUDIES IN METHANOGENESIS (PRODUCTION OF METHANE, SLUDGE FERTILIZER AND HIGH PROTEIN FEED FOR AGRICULTURAL WASTES)

R. Ross, University of Hawaii System, Manoa Campus, Agricultural Experiment Station, Dept. of Animal Science, *Gilmore Hall, Room 102, Honolulu, Hawaii* 96822

Description: Justification: Methanogenesis, the anaerobic fermentation of animal wastes and plant materials to produce methane, may be the solution to a number of problems concerning the energy crisis, animal waste management, wasted plant materials, food production and the environment. Ideally, it could solve manure disposal problems for animal producers, produce a fuel that could substitute for fossil fuels, and alleviate the problems of pollution caused by residues of burning fossil fuel. Objectives: Develop, perfect and biologically define an animal waste recycling system(s) for Hawaii which would help solve the animal waste disposal problem and produce some economically valuable by-products (methane, sludge fertilizer and possibly a high protein feed). Approach: A two-phase experimental approach will be utilized. The first will involve small-scale, controlled laboratory digester experiments to find an optimum set of conditions for maximum methane production. The second phase will involve a pilot plant designed to provide maximum research versatility, thus allowing for (1) comparison of single vs. series digester systems, (2) comparison of single vs. series digester systems. Progress report: (1) A trial is being conducted to determine the chemical composition of feedlot manure during a six-month fattening period. The manure sampled during the first month has been high in crude protein, 14-20% on a D.M.B. (2) Fifty Gallon anaerobic digesters are being constructed to be used in a trial to test the effectiveness of different types of solar heaters to maintain proper digester temperature. (3) Small-scale (4 liter) laboratory digesters are being used as models to test for effectiveness of stirring and effect of temperature and total solids on gas production.

Addenda: Estimated calendar year funding reported as 1975 $32,000. This project is also supported by: ENCOTECH.

SUPPORTED BY University of Hawaii

2.0068,

DESIGN PARAMETERS AND EQUATIONS FOR ANAEROBIC BIOCONVERSION OF ORGANIC WASTES

P. Yang, University of Hawaii System, Manoa Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Gilmore Hall, Room 102, Honolulu, Hawaii* 96822 (HAW00528-S)

OBJECTIVE: Evaluate the rate constants (based on biological concepts) and equations for the design and prediction of production of methane and degree of stabilization of organic waste in the batch, semi-continuous flow with constant solid recycle systems. Investigate the operational stability of constant sludge recycle system at normal and shock loading conditions.

APPROACH: Laboratory and pilot scale operations will be used for the evaluation of design parameters for batch operations. These parameters will be applied as the design criteria for the development and operation of semi-continuous flow and constant sludge concentration recycled continuous flow systems. Animal wastes, crop residues, and sewage treatment sludge will be used for demonstrating the application of design parameters evaluated from laboratory and pilot scale studies.

SUPPORTED BY Hawaii State Government

2.0069,

METHANE PRODUCTION FROM BIOCONVERSION OF ORGANIC MATERIAL

G. Dugan, University of Hawaii System, Manoa Campus, School of Engineering, Dept. of Civil Engin, *Bachman Hall, Honolulu, Hawaii* 96822

Progress to date includes the assembling of necessary laboratory supplies and equipment, and the design and fabrication of three 55-gallon liquid capacity pilot plant digesters. Presently, five one-gallon digesters are in operation: Three using cattle manure; one using pig manure; and one using chicken manure. All one-gallon digesters appear to be fnctioning adequately and producing gas with increased organic loading. Two of the cattle manure digesters will be used for 'seeding' a 55-gallon digester in an effort to enhance acclimation. The three pilot plant digesters will serve as in-depth simulation of field conditions for the further study of the organic material that presents the most optimum promise of producing high quantities of methane gas, as determined by the one-gallon bench-size glass digesters.

SUPPORTED BY Hawaii State Government

2.0070,

MODELING FOREST BIOMASS IN CEDAR/HEMLOCK/GRAND FIR ECOSYSTEM

C.R. Hatch, University of Idaho, Forest Wildlife & Range Experiment Station, *Moscow, Idaho* 83843 (IDA-ES-0082)

OBJECTIVE: Provide predictive models of the development of crown components of forest biomass. Develop a model for the conversion of live to dead biomass and for deterioration and decomposition of dead biomass.

APPROACH: Data from the Forest Service fuel science project (RWU 2104) will be analyzed to obtain functional relationships of distribution of true biomass by size classes. Data on transition of live crown to dead branchwood will also be analyzed, as well as mortality samples,to determine rates of decomposition. A predictive model framework will then be developed and checked against available data.

SUPPORTED BY Idaho State Government

2.0071,

INVESTIGATION OF UNCONVENTIONAL SOURCES OF ENERGY

L.R. Johnson, University of Idaho, School of Forestry Wildlife & Range Sciences, Dept. of Forest Products, *Moscow, Idaho* 83843 (IDA-ES-0121)

OBJECTIVE: Determine quantities and costs of energy available from unconventional energy sources in the Pacific Northwest (Washington, Oregon, Idaho) and the state of knowledge in converting these energy sources (Forest biomass) to usable forms of energy.

APPROACH: Review published literature and ongoing studies for state of knowledge regarding conversion systems, quantities, and costs. Using this information, determine the cost and quantities of energy available (realistically) to the Pacific Northwest from unconventional sources. The most promising are then subjected to detailed study regarding their use and potential impact of these sources on future Northwest needs.

PROGRESS: Extensive review of literature and ongoing studies in field of unconventional energy sources resulted in development of annotated bibliography of the field and a preliminary analysis of the quantities and costs of using unconventional energy sources in the northwest (Washington, Oregon, Idaho). The alternatives investigated in the preliminary analysis were reduced in number to the most likely candidates and these subjected to a more detailed analysis with projections of the impact these sources might have on Northwest energy supplies. Intermediate report was completed in July showing bibliography and preliminary analysis. Final draft is being reviewed and when completed will be published through NTIS.

SUPPORTED BY Idaho State Government

2.0072,

SYMPOSIUM - MANAGEMENT AND UTILIZATION OF ANIMAL WASTES

A.L. Sutton, American Society of Animal Science, Dept. of Animal Science, *113 N. Neil St., Champaign, Illinois* 61820 (L770D-3-36)

The objective of this symposium is to discuss advancements in the state of the art in certain areas of the management and utilization of animal wastes with pollution abatement. Scientists attending this symposium will be exposed to research information, critical evaluations and practical experiences related to waste processing and refeeding, regulatory concerns, methane digesters and other nutrient recovery systems, new waste handling techniques and economic comparisons of waste management systems.

This symposium is designed to critically evaluate and share experiences on these topics by researchers, businessmen and regulatory officials involved in these areas.

The ultimate benefit of this symposium is that from the information presented, scientists, environmentalists, regulatory agencies, livestock producers, and the general public will know (1) what management systems appear useful in efficiently utilizing nutrients in waste while controlling pollution and (2) what problems exist with current management systems and future research information needs.

A one-half day symposium will be held during a joint annual meeting of the American Society of Animal Science and American Dairy Science Association, East Lansing, Michigan, July 9-13, 1978. Manuscripts of the symposium will be published in the Journal of Animal Science.

Project has been funded as of July 1978.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Robert S. Kerr Environmental Research Lab.

2.0073,

UTILIZATION OF REJECTED HEAT FROM ELECTRIC POWER PLANTS IN CONNECTION WITH WATER RESOURCES

R.W. Porter, Illinois Inst. of Technology, School of Engineering & Physical Science, Dept. of Mech & Mechanical & Aerosp Eng, *3300 S. Federal St., Chicago, Illinois* 60616 (EC-77-S-02-4531)

The emphasis is on conserving energy by both maintaining a high thermal efficiency of the electrical generating station and beneficially utilizing the rejected heat in connection with water resource management. The applications include potable water treatment, wastewater treatment, and spray irrigation. The use of waste heat to warm potable water supplies may increase the treatment efficiency of filtration and disinfection, energy costs of water heating will be reduced, and sewage temperatures would be increased enhancing the efficiency of waste treatment indirectly. In the case of (direct) wastewater treatment, waste heat may be employed to increase the effectiveness of mechanical, chemical, and biological processes. In particular, an atmospheric spray cooling device may be used to provide long-term aeration cycling and sludge may be used to supplement fossil fuel as an additive and to produce methane for either boiler fuel or a pipeline product. The use of heated water in spray irrigation has the advantage that the heat is spread over a large area although the water is substantially cooled before it strikes the ground, the growing season may be extended, and frost damage may be alleviated. The objective is to determine the engineering feasibility of the above schemes including operational, economic, legal, and environmental implications and to assess prospects for implementation. The proposed investigation centers about a systems analysis of the three applications. Simultaneously, supporting field experimental, laboratory wind tunnel, and theoretical analyses will be carried out. The field studies at large operating power plants include determination of aeration and thermal characteristics of atmospheric sprays. The wind tunnels include a spray cross-flow facility for analyzing heat, mass, and momentum transfer simultaneously and an environmental facility for analyzing dispersion to the atmosphere from large distributed source. The theoretical studies consider the description of aeration and thermal performance and atmospheric dispersion.

SUPPORTED BY U.S. Dept. of Energy

2.0074,

SOLAR ENERGY CONVERSION

J.J. Katz, U.S. Dept. of Energy, Argonne National Lab., *9700 S. Cass Ave., Argonne, Illinois* 60439 (EE-03-01-01)

Solar energy is the only truly renewable energy source available, and effective use of solar energy is crucial to a long-term solution of the energy problem. Conventional approaches to solar energy involves light collection and (1) direct conversion of light to electricity by various solid-state devices, or (2) use as a heat source. Our approach, on the other hand, is biomimetic. Nature has evolved a very efficient process for light energy conversion in photosynthesis, the reaction whereby plants use light energy from the sun for chemical synthesis. Plants are very efficient collectors and converters of light energy, and we propose to use plant photosynthesis as a model for light energy conversion. The essential ingredient in the light energy conversion process in photosynthetic organisms is chlorophyll, an effective absorber and converter of light energy. In a biomimetic approach, chlorophyll and the photosynthesis process in general (where light is converted very efficiently to chemical oxidation-reduction potential) can serve as the basis for a design of a solar energy conversion scheme, with production of hydrogen

and/or other substances capable of acting as fuels as our ultimate goal.
SUPPORTED BY U.S. Dept. of Energy, Office of Energy Research

2.0075,
MICROBIOLOGY OF THE THERMOPHILIC METHANOGENESIS IN CATTLE WASTE

M.P. Bryant, University of Illinois, Urbana Champaign Campus, Agricultural Experiment Station, Dept. of Dairy Science, *Urbana, Illinois* 61801 (ILLU-35-0331)
OBJECTIVE: Obtain fundamental information on the microbial and biochemical ecology of the bacterial system involved in production of methane from cattle waste under thermophilic conditions (60 C) so that detailed information will be available concerning the pathways of metabolism, major kinds of bacteria responsible for specific metabolic reactions and metabolic and nutritional interactions involved in efficient methanogenesis.
APPROACH: Isolate and characterize the major groups of bacteria involved in rapid and efficient degradation of organic matter of cattle waste to methane and CO(2) under anaerobic conditions at 60 C. Major emphasis will be placed on bacteria responsible for fiber, protein and lipid degradation, those involved in degrading intermediates such as fatty acids to acetate, and species directly producing methane from acetate and hydrogen and determination of features of importance to establishment of their specific functions in the ecosystem.
PROGRESS: Various aspects of the microbiology of methanogenesis from 60 C reactors fed 7% of organic matter of cattle waste as a 6 day retention time revealed that many thermophilic bacteria are present in the waste as fed. This helps to explain the rapid start-up previously shown for thermophilic reactors. The only methanogenic bacteria (more than 10 /g) isolated from the reactor was Methanobacterium thermoautotrophicum a species which uses only H(2)-CO(2). Acetate utilizers have not yet been isolated. Data on pool size and turnover rates indicate that 65-90% (depending on time after feeding) of the methane is produced via butyrate oxidation, but contrary to mesophilic fermentations, little seems to be produced via propionate oxidation. Thermophilic pentosan and cellulose fermenting species of anaerobic bacteria, present in large numbers, have been isolated from the reactors.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Illinois

2.0076,
THERMOPHILIC METHANOGENESIS FROM CATTLE WASTES

M.P. Bryant, University of Illinois, Urbana Champaign Campus, Agricultural Experiment Station, Dept. of Dairy Science, *Urbana, Illinois* 61801 (ILLU-35-0352)
OBJECTIVE: Obtain data on optimum conditions of loading rate and retention time for efficient microbial methanogenesis, protein synthesis and digestion of organic matter from feedlot and dairy cattle wastes at 60 C. Other organic wastes will be studied at the appropriate feed rate to determine their utility as sources of methane. Detailed chemical analyses will be done to determine the nature of material digested and to use in establishment of equations for prediction of organic matter digestion and methanogenesis rate. Food value of microbial protein will be evaluated.
APPROACH: Most work will be done with 3-liter digestors fed one-a-day and chemical analyses will include those useful in forage analyses and sanitary engineering.
PROGRESS: Dairy cattle wastes (feces and urine) collected from lactating dairy cows fed either a high-roughage (80% D.M. from roughage) or low-roughage (approx. 50% D.M from roughage) have been subjected to a thermophilic fermentation at 60 C. This study was designed to establish the effects of loading rate (4, 6, 8, 10, 12, 14% volatile solids) and retention time (9, 6 and 3 days) on volatile solid (V.S.) destruction and methane production. The results show that V.S. destruction as a percent of that fed (difference 31%) was highest in fermentors operating at 9 day retention times and fed waste containing 4-8% V.S. However, much higher absolute amounts of V.S. were degraded in fermentors set at 3-day retention times and fed wastes containing 6 to 10% V.S. Loading rates involving 12 or 14% V.S. waste reduced the fermentation causing an accumulation of NH(3) and organic acids and a decrease in alkalinity in the contents of the fermentor. Methane (CH(4)) production expressed either as ml/g V.S. fed or liters/liter or reactor/day essentially paralled the data on V.S. destruction. The highest rate of CH(4) production (2.9 liter CH(4)/liter reactor/day) was observed in fermentors operating at a retention time of 3 days and fed waste containing 10% V.S. The % CH(4) of the total gases produced ranged from 51-54 in all fermentors in a steady state.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Illinois

2.0077,
ELECTROCHEMICAL CONVERSION OF ANIMAL WASTES INTO PROTEIN AND HYDROGEN

D.L. Day, University of Illinois, Urbana Champaign Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Urbana, Illinois* 61801 (ILLU-10-0376)
OBJECTIVE: Investigate the technical feasibility of replacing mechanical aeration with electrochemical oxidation of livestock wastes to produce feed protein and by-product hydrogen. Upgrading the nitrogen to protein is of special importance for refeeding to nonruminants as an alternative to spreading wastes on land while achieving pollution control.
APPROACH: Initial studies will use a laboratory bench scale electrolytic cell wherein liquid swine manure will serve as the electrolyte. Aerobic bacteria will utilize oxygen as it is produced at the anode and hydrogen, a potential fuel of the future, will be produced at the anode. Low voltage direct current electricity will run the apparatus. Technical operational parameters will be studied to achieve optimum growth of single cell protein and production of hydrogen.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Illinois

2.0078,
SOLAR ENERGY CONVERSION THROUGH WOODY BIOMASS PRODUCTION

G.L. Rolfe, University of Illinois, Urbana Champaign Campus, Agricultural Experiment Station, Mcintire Stennis Program, *Urbana, Illinois* 61801 (ILLU-55-342)
OBJECTIVE: Develop a net energy balance for energy plantations. Determine relationships between four woody species and biomass yield. Determine the optimum spacing and cutting cycle for these species. Determine the nutrient requirements and best method of supplying these nutrients for sustained biomass yield. Develop site selection criteria in order to determine those marginal lands best suited for energy production.
APPROACH: A series of field test plots will be established on a range of sites in central and southern Illinois to evaluate the potential of various species for maximum biomass production for energy conversion. Nutrient requirements will also be determined through tissue and soil analysis during the growth period. Energy yields will be measured and a net energy balance developed.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Illinois

2.0079,
ECONOMICS OF ANIMAL WASTE MANAGEMENT AND ENVIRONMENTAL QUALITY

R.N. VanArsdall, University of Illinois, Urbana Champaign Campus, Agricultural Experiment Station, Dept. of Agricultural Econ, *Urbana, Illinois* 61801 (NRE-41-302-17-01)
OBJECTIVE: Evaluate the economic impact on livestock farmers, consumers, processors, marketing firms, and taxpayers of proposed and potential guidelines; evaluate alternative animal waste systems; and determine least-cost abatement practices.
APPROACH: The cattle feeding, dairy, hog, and poultry portions of the livestock industry will be studied. First, attention will focus on the economic impact of proposed point source effluent limitation guidelines. Secondly, the economic impact of alternative measures and guidelines relating to the control of nonpoint sources of animal waste will be analyzed. The basic analytical approach will be a series of partial equilibrium analyses employing budgeting and linear programming techniques.
PROGRESS: Over one-fifth of all farms producing hogs in the 15 major hog-producing states were estimated to have runoff problems. The impact of runoff control would fall more heavily on small producers. Farms selling fewer than 100 hogs annually would incur investments of about $61 per hog and additional annual costs of $4.24 per 100 pounds of hogs sold. Farms with output above 1,000 hogs would require $4.00 investment per hogs and $0.26 of additional operating costs per 100 pounds. However, after adjustments to comply with environmental regulations are completed, pork will be little or no more expensive to the consumer. Feedlots of over 2,000 head capacity accounted for 58 percent of all feed cattle marketings in the U.S. in 1973. Fifty-six percent of the feedlots spread manure on land that they operate. The average application rate was 18 tons per acre. The value of gas (fuel) and sludge (fertilizer) from anaerobic production of methane from animal waste is expected to exceed annual costs if the output can be fully used. Michigan feedlots would adjust to pollution abatement controls by modest reductions in beef output.
SUPPORTED BY U.S. Dept. of Agriculture, Economics Statistics & Cooperatives Service, Natural Resource Economics Div.

2.0080,
THE CONVERSION OF FERMENTED WASTE INTO PANEL PRODUCTS

C.S. Walters, University of Illinois, Urbana Champaign Campus, Agricultural Experiment Station, Dept. of Forestry, *Urbana, Illinois* 61801 (ILLU-55-0337)
OBJECTIVE: Study the conversion of a fermented, organic, waste-residue into hot-pressed panels. Determine the physical and mechanical properties of panelboards made from fermented waste.
APPROACH: The feasibility of manufacturing methane, a source of energy, by anaerobic fermentation of domestic, organic waste, has been demonstrated. A residue is left for disposal; however, empirical test have shown that converting the fermented residue into hot-pressed panels and molded fiber productsis a highly promising method of utilizing the residue. The properties of boards made, with and without a binder, will be determined. The conversion will yield income, convert a waste into usable products, eliminate a disposal problem, and conserve a natural resource.
PROGRESS: Twenty-four 1/4-inch panel boards were made of residue from the fermentation of shredded, solid, organic waste. Boards containing no phenol-formaldehyde adhesive, or 2%, 4%, or 8% of the dry weight of the furnish were wet formed, then hot-pressed. Boards were post-cured at 140 C for 15, 30 or 45 minutes. The mean specific gravity was 0.73 or - 0.06. The MOR ranged from 510 psi for a sample with no resin and post-cured 30 minutes, to 1520 psi for one with 2% resin and post-cured 45 minutes. MOR was correlated with specific gravity (X) of the board: MOR, psi = 1453(X) - 52. The mean MOE ranged from 68,930 psi for a sample with no resin and cured 30 minutes to 171,390 psi for a sample with 2% resin and cured 45 minutes. The mean internal bond ranged from 10.6 or - 5.8 psi to 34.0 or - 4.6 psi. The mean modulus of hardness was 6400 or - 2000 lbs/in. Linear expansion was less than 1 percent when the specimens were transferred from an environment of 20 C-50%RH (with 8% resin, 26 C-50%RH) to one with 20 C and 90% RH. Percentage of swelling was only a fraction of what one would expect for solid wood, apparently the result of fermentation. The mean moisture content for specimens containing no adhesive and conditioned at 20 C and 65% RH was 6.1 or - 1.4 percent.
SUPPORTED BY Illinois State Government

2.0081,
BIOLOGICAL CONVERSION OF BIOMASS TO METHANE

J.T. Pfeffer, University of Illinois, Urbana Champaign Campus, School of Engineering, Dept. of Civil Engin, *2527 Hydrosystems Lab., Urbana, Illinois* 61801 (EY-76-S-02-2917)
Past research on the biological conversion of organic urban refuse to methane has shown that it is a technically feasible process. The economics appear to be favorable. Additional organic solids are available from crop residues, animal manures and crops grown specifically for energy production. An experimental fermentation system consisting of four 900 liter continuous feed fermenters will be used for this study. The above organic solids will be used as substrate. The optimum mesophilic and thermophilic temperatures will be determined. The kinetics of methane production will be evaluated at these temperatures. In addition, data on the dewatering properties of the slurry and the characteristics of the residue will be obtained. A simulation model currently being used to model the system for producing meth-

ane from urban refuse will be adapted for use in evaluating these substrates. The data obtained from the experimental work will be input for this simulator. The cost of methane production under various operating conditions can be predicted with the simulator.
SUPPORTED BY U.S. Dept. of Energy, Unspecified Unit

2.0082,

BIOLOGICAL CONVERSION OF ORGANIC REFUSE TO METHANE

J.T. Pfeffer, University of Illinois, Urbana Champaign Campus, School of Engineering, Dept. of Civil Engin, *2527 Hydrosystems Lab., Urbana, Illinois* 61801 (E(11-1)-2917)

This is a continuation of the grant NSF/AER 73-07872. Past research on the biological conversion of organic urban refuse to methane has shown that it is a technically feasible process. The economics appear to be favorable. Additional organic solids are available from crop residues, animal manures and crops grown specifically for energy production. In order to predict the cost of methane generated from these substrates, experimental data on the conversion efficiency (gas yield) and the residue dewatering and disposal characteristics must be obtained. An experimental fermentation system consisting of four 900 liter continuous feed fermentors will be used for this study. Fermentors will be operated at mesophilic and thermophilic temperatures simultaneously. The above organic solids will be used as substrate. Thermochemically treated fibers will be the substrate for two fermentors while the other two fermentors receive untreated fibers. The optimum mesophilic and thermophilic temperature will be determined. The kinetics of methane production will be evaluated at these temperatures. In addition, data on the dewatering properties of the slurry and the characteristics of the residue will be obtained. A simulation model currently being used to model the system for producing methane from urban refuse will be adapted for use in evaluating these substrates. The data obtained from the experimental work will be input for this simulator. The cost of methane production under various operating conditions can be predicted with the simulator. (ERDA 76-137)

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0083,

PLUG FLOW VS. COMPLETE MIX REACTORS FOR METHANE FERMENTATION

J.T. Pfeffer, University of Illinois, Urbana Champaign Campus, School of Engineering, Dept. of Civil Engineering, *2527 Hydrosystems Lab., Urbana, Illinois* 61801 (E(11-1)-2917)

The advantage of and need for mixing in the anaerobic fermentation of sewage sludges has long been recognized. Because of the sequential nature of the microbial process, mixing has provided more stable systems that are less subject to operational problems. Recent reports have suggested that plug flow reactors are capable of providing higher rates of stabilization which results in greater methane production per unit volume of reactor. It has also been reported that separation of the acetogenic stage from the methogenic stage increases the gas yield. The theoretical basis for the use of plug flow, two stage, and complete mix reactors will be evaluated. An experimental program will be conducted to determine conversion rates, yields, and operating conditions in fermentation of biomass. These data will be used to evaluate the efficiency of reactor design for fermentation of biomass materials. (ERDA 77-31)

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0084,

METHYL TRANSFER REACTIONS AND THE BIOCHEMISTRY OF METHANOGENESIS

R.S. Wolfe, University of Illinois, Urbana Champaign Campus, School of Liberal Arts & Sciences, Dept. of Microbiology, *Urbana, Illinois* 61801

Various aspects of methane formation from bacteria are under investigation. Studies on Coenzyme M and the associated methylreductase are aimed at resolving and characterizing the proteins and cofactors as well as the role of ATP in activation of the enzyme, and elucidating the nature of coenzyme M analog inhibition and the electron donors for methyl-group reduction. Studies will be continued on the chemical structure of coenzyme F420 and its protein-coenzyme association, on the activation and reduction of CO_2 to the methyl level, the hydrogenases of methane bacteria, and the enzymic transfer of the methyl group in Methanosarcina Barkeri. Experiments will be initiated on the isolation of methane bacteria which are major acetate degraders.

An unusual organism has been isolated from fermenting seaweed which grows on hydrogen and carbon dioxide and synthesizes acetate. This anaerobe is not a methane bacterium. It should be possible now to investigate what appears to be one of the last unstudied energy generating systems in anaerobes.

SUPPORTED BY U.S. National Science Foundation, Div. of Physiology Cellular & Molecular Biology

2.0085,

ANIMAL WASTE MANAGEMENT WITH POLLUTION CONTROL

A.C. Dale, Purdue University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Executive Bldg., West Lafayette, Indiana* 47907 (IND01725)

OBJECTIVE: Further develop animal waste management systems to control odors and toxic materials in air and organic materials, organisms, nutrients and chemicals in water and soil, compatible with efficient livestock production and cropping practices in the areas of collection, transport and management of wastes. Treatment and conditioning of wastes, and utilization and/or disposal of wastes.

APPROACH: Laboratory studies will be set-up to find the effect of temperature, time, size and particle, micro-organism, and loading rates on odor control and decomposition of dairy cattle wastes; initiate a laboratory study using an anaerobic chamber followed by an aerobic chamber to determine the percentage of solids of livestock wastes which can be decomposed; a field trial of a deep aerated lagoon and irrigation system will be set-up to evaluate such a method for returning dairy cattle and swine wastes to land; oxidation ditches will be monitored at the Purdue Swine Farms to evaluate feasibility for treating and disposing of swine wastes.

PROGRESS: Research continued on the development of the 'bag' concept for the improvement of methane production from animal wastes. The main objective is to find out if an improved digester for the breakdown of volatile solids and the production of methane can be developed. One of the main difficulties often encountered in methane production is loss of the organism by being 'washed out' in the effluent or being killed off by a malfunctioning digester. With the 'bag' concept, effort is being made to increase and improve the culture for an improved 'breakdown' of the organic matter along with the production of a greater quantity of methane per pound of volatile solids. Currently, the bag method is being compared to high rate digesters with respect to methane production and solids reduction. An investigation has also started on the possibility of growing and using algae as a source of energy for a methane digester. Animal wastes are to be used as a fertilizer to improve the growth of the algae which would in turn be collected and fed to the digester. A fast reproducing, single cell organism such as the Chlorella is under consideration for such use.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Indiana

2.0086,

ANIMAL WASTE MANAGEMENT SYSTEMS FOR THE 1980'S

A.C. Dale, Purdue University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Executive Bldg., West Lafayette, Indiana* 47907 (IND046015 A)

OBJECTIVE: Develop optimal animal manure management systems to meet evolving environmental and economic requirements; investigate use of by-products of animal manure management systems for energy sources, feed ingredients, plant nutrients for crop production and other potential uses.

APPROACH: Complete flushing systems in conjunction with one, two and three-stage lagoons are to be tried for swine production systems. Observations are to be made on a run-off storage and irrigation system for a dairy cow operation. Responses of crops to various levels of application of swine and dairy cattle manure are to be observed. The synthesis of wastes by single cell bacteria is to be continued. Methane production research is to be continued.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Indiana

2.0087,

A FUNDAMENTAL STUDY OF THE MECHANISM AND KINETICS OF CELLULOSE HYDROLYSIS BY ACIDS AND ENZYMES

G.T. Tsao, Purdue University, School of Chemical Engineering, *Executive Bldg., West Lafayette, Indiana* 47907 (EY-76-S-02-2755)

The long term objective of this research is to utilize cellulosic wastes as an alternative source of fuels, chemicals and other useful products. This project deals with a number of fundamental problems. Cellulase system of Tricoderma viride is to be purfied and kinetics of the pure cellulase components will first be studied individually. Biosynthesis, genetic control and the problem of multiplicity of cellulases of T. viride will be studied.

After re-precipitated from a solvent, cellulose structure is apparently very different from its native form. Reprecipitated cellulose can be easily hydrolyzed. This project will also investigate the effects of solvents on structure changes.

RESULTS: (1) C1, Cx and cellubiase components have been all isolated and purified. (2) Kinetics of cellubiase are completely investigated. (3) Kinetics of C1 and Cx on hydrolysis of soluble cellooligomers have been largely completed. (4) A number of solvents are found to dissolve cellulose and reprecipitated cellulose can be easily hydrolyzed by either acids or enzymes.

SUPPORTED BY U.S. Dept. of Energy

2.0088,

CELLULOSE HYDROLYSIS WITH AND WITHOUT PRETREATMENT - KINETICS AND PROCESS DESIGN

G.T. Tsao, Purdue University, School of Engineering, Dept. of Chemical Engin, *Executive Bldg., West Lafayette, Indiana* 47907

The overall objective of the research is to utilize cellulose more effectively for the production of foods, chemicals, and fuels. Specifically, the research will focus on the kinetics and process design of hydrolyzing cellulose, nature's most abundant organic material, to glucose in a two-stage process employing first chemical and then enzymatic means. Research will involve the preparation and purification of cellulase enzymes, their partial characterization, an evaluation of the various cellulose pretreatment methods such as HCl, SO_2 and oxides of nitrogen in conjunction with a follow-up enzymatic treatment, and an economic analysis of the overall two-stage, acid-enzyme process.

SUPPORTED BY U.S. National Science Foundation, Div. of Advanced Energy & Resources Research & Technology

2.0089,

AN INTEGRATED FARM ENERGY SUPPLY SYSTEM FOR THE IOWA FARM

W.F. Buchele, Iowa State University of Science & Technology, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Beardshear Hall, Ames, Iowa* 50010 (IOW02312)

OBJECTIVE: Develop and promote the use of farm size distilleries in an integrated energy system for the Iowa farm. Develop and promote the use of corn-cob gasifiers on tractors in an integrated energy system for the Iowa farm.

APPROACH: Chemical and engineering analysis will be used to disign, construct and develop a corn-fed farm size distillery and a corncob producer gas generator.

SUPPORTED BY Iowa State Government

2.0090,

DEVELOPMENT OF BIO-MASS SYSTEMS FOR DRYING CORN

W.F. Buchele, Iowa State University of Science & Technology, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Beardshear Hall, Ames, Iowa* 50010 (IOW02325)

OBJECTIVE: Design, construct, develop, test and promote the use of a cornstalk fueled furnace for grain drying bins. Both direct and heat exchanger furnaces will be developed.

APPROACH: Combustion engineering and grain drying principles will be combined to produce an economical design of a cornstalk fueled furnace. Controls will be developed to operate the furnace and control the hot air supply to the grain bin.

SUPPORTED BY Iowa State Government

2.0091,

CAUSES, CONSEQUENCES AND ECONOMIC CONTROL OF CROP CHEMICAL POLLUTION

J.A. Miranowski, Iowa State University of Science & Technology, Agricultural Experiment Station, Dept. of Agricultural Econ, *Beardshear Hall, Ames, Iowa* 50010 (IOW02133)

OBJECTIVE: Given the growing concern about environmental damage from crop chemicals, this investigation will incorporate a research strategy designed to isolate the causes, consequences, and control of these non-point source pollutants. First, the relationship between crop chemical application levels and potential pollution levels will be investigated. Second, proxy measures of the pesticide and fertilizer damage functions will be developed. Third, the energy implications of crop chemical control policies will be estimated. Finally, policy options for crop chemical use control will be evaluated.

APPROACH: Estimate the relationship between crop chemical use and stream chemical concentrations; develop environmental damage measures based on characteristics of the crop chemicals concerned and available damage costs; estimate energy requirements, both direct and indirect, associated with different levels of crop chemical use; evaluate alternative policy options to control crop chemical use and the associated social costs.

PROGRESS: Three components of the economic system have received further development. First, a preliminary multiple regression model was developed to assess the relationship between fertilization level and nitrate concentration in the Skunk River. The results of this model are being used to evaluate the efficiency and efficacy of alternative residual control policies. Second, new data and estimation were introduced into the fertilizer demand model to assess farmer response to fertilizer price and user charges to control nitrate residuals. Third, the linear programming model for a representative Iowa farm was used to assess the impact of energy prices on the choice of crops produced and the adoption of on-farm methane generation and excreta silage feeding. Moderate energy price increases have little impact on the optimal linear programming solutions, but more drastic energy price increases do alter the mix of activities, and output the input levels. Currently, excreta silage feeding is economically feasible, but the methane digestor is a less promising alternative.

SUPPORTED BY Iowa State Government

2.0092,

QUANTITATIVE ANALYSIS OF WOOD FIBER YIELD

L.C. Promnitz, Iowa State University of Science & Technology, Agricultural Experiment Station, Mcintire Stennis Program, *Beardshear Hall, Ames, Iowa* 50010 (IOW02129)

OBJECTIVE: Quantitatively evaluate woody plant yield under intensive culture systems. Evaluate the impact of physiological parameters on growth and design genetically optimal trees and stands.

APPROACH: Through use of mathematical relationships developed from controlled environment data on plant structure, photosynthesis, and distribution of photosynthate, predict field performance. Use field data to verify and refine predictions. Through computer simulation, extrapolate basic data.

PROGRESS: Completed initial 3-year studies on effects of location, clone and density on growth and yield of intensively managed Populus. Beginning analysis of experiment and development of physiologically based growth and yield models. Initiated study on coppice regeneration as related to root system structure within an intensive culture context.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Iowa

2.0093,

POTENTIAL FOR ENERGY PRODUCTION ON A 320-ACRE IOWA FARM

R.J. Smith, Iowa State University of Science & Technology, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Beardshear Hall, Ames, Iowa* 50010 (1090-16064-003-C)

OBJECTIVE: Obtain a technological and economic assessment of the feasibility of making a 320-acre Iowa farm energy self-sufficient by generation of methane.

APPROACH: The total 320-acre farm system will be examined to determine the potential of incorporating extensive recycling of residues through both plants and animals with a bioconversion system for the production of energy. The addition of the bioconversion system will be evaluated in terms of optimizing all farm management and production systems. Where new equipment items are needed, they will be designed and construction drawings and specifications prepared.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Beltsville Agricultural Research Center

2.0094,

ANIMAL WASTE MANAGEMENT SYSTEMS FOR THE 1980'S

R.J. Smith, Iowa State University of Science & Technology, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Beardshear Hall, Ames, Iowa* 50010 (IOW02126)

OBJECTIVE: Conceptualize, develop, analyze and optimize animal manure management systems with least cost and energy requirements for pollution control compatible with changing socio-politico-economic patterns. Specific objectives are: Develop optimal animal manure management systems to meet the evolving environmental and economic requirements and be compatible with the increasing needs of our nation and the world for animal protein. Characterize atmospheric contaminants and develop abatement methods to eliminate the contaminants potentially harmful effects on human and animal health. Investigate use of by-products of animal manure management systems for energy sources, feed ingredients, plant nutrients for crop production and other potential uses with consideration of the human, animal and plant health factors.

APPROACH: Pilot scale work on surface aeration of lagoons will be scaled up for a full size lagoon. Results obtained from a 100 gallon existing anaerobic digester will be extended to a pilot scale unit for several beef animals. Cooperative work with animal scientists will determine the feasibility of using digester effluent to produce stover silage. Observer panels will correlate odors from various livestock production systems with chemical odor standards.

PROGRESS: 1. A model study of the energy-producing potential of anaerobic fermentation of manure from a typical 320 ac Iowa farm showed that an engine-generator fuelled by digester gas could supply about 75% of the farmstead electrical-energy demand; useful thermal energy as hot water would also be available. A 300-head beef unit and a 50-sow farrow-to-finish herd were specified. 2. An 8-ft diameter floating cover was used to isolate part of an anaerobic lagoon serving 600 pigs. The top 3 ft of the lagoon under the cover could be aerated intermittently. Active gas production was observed and measured. The measure of odor used was H(2)S. Aeration reduced H(2)S concentration in the gas evolved. 3. Mixing energy for a beef-waste digester of 100-gal capacity has been examined. Initially, gas-recirculation mixing was used but was not satisfactory. Solids settled and could not be resuspended. Propeller mixing, used intermittently, proved more satisfactory. Organic load reduction and gas production were used as measures of digester operation. Performance has been erratic because of biological upsets.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Iowa

2.0095,

FAST PRODUCTION OF METHANE AND BACTERIAL PROTEIN BY ANAEROBIC DIGESTION

C.D. Finney, Natural Dynamics, *Des Moines, Iowa* 50311

To account for very slow methane bacteria reproduction in conventional anaerobic digestion, the investigator introduced the hypothesis that phase transfer of digestion products is rate limiting and product gas bubbles inhibit bacterial growth. In testing this hypothesis, the investigator found that the rate at which bacteria produce methane from raw cellulose (i.e. wood chips, sewage, and livestock waste) is actually slowed by the existence of bubbles of gas in the digesting medium thereby interfering with normal metabolic processes. It was found that by manipulating the temperature, pressure and viscosity of the reaction, gas at a rate 2.1 times that of the fastest, stable prior act value was produced. It is predicted that an energy efficiency of 40 to 60 percent can probably be achieved in a two-step reaction chain providing the factors of temperature and mixing are carefully controlled. This study further indicates that about 8 percent of the material (glucose) added to fuel the bacteria was converted to bacterial cell protein. The dollar value of the protein material, which might be used as a primary animal feedstock, is said to be about equal to that of the methane gas. The investigator believes the added economic leverage of the bacterial protein increases the attractiveness of the proposed technology.

SUPPORTED BY U.S. Dept. of Energy

2.0096,

HIGH-RATE ANAEROBIC DIGESTION

C.D. Finney, Natural Dynamics, *Des Moines, Iowa* 50311 (EY-76-C-02-2900)

Investigate the possibility that anaerobic digestion in low viscosity solutions and at negative pressures can increase methane production by a factor of three to six. This effort will test the hypothesis that the phase transfer of methane is the rate limiting step in the optimization of anaerobic digestion. Confirmation will be sought to substantiate that reduced pressure and separation of the acidogenous and/or hydrolysis stages from the methanogenous stage to reduce fluid viscosity is desirable. This could result in a 4 to 6-fold increase in methane-rich gas generation to 4 to 14 grams/liter per day. During FY78 the concept of fast methane generation will be tested on a bench scale and development of a hydrolysis-acidogenesis-methanogenous concept continued.

SUPPORTED BY U.S. Dept. of Energy, Div. of Buildings & Community Systems

2.0097,

DEVELOP A METHANE AND FERTILIZER SYSTEM FOR FARM USE

C.P. Allen, Sunny Time Foods Inc., *Dubuque, Iowa* 52001

Construct an energy-efficient methane gas digester fueled with pure animal waste on a poultry farm. Burn the methane to produce electricity. Waste heat will be used to maintain digester temperature; electric power will run the farm and gas system. Apply discharged liquids as fertilizer to maximize benefits and minimize environmental impact.

SUPPORTED BY Iowa State Government

2.0098,

OPTIMIZATION TECHNIQUES FOR AGRICULTURAL PROBLEMS

L.T. Fan, Kansas State University, Agricultural Experiment Station, Dept. of Chemical Engin, *Anderson Hall, Manhattan, Kansas* 66502 (KAN00737)

OBJECTIVE: Apply systems analysis and systems optimization to agricultural problems. Simulation, optimal design, and optimal control techniques will be developed and demonstrated by application to important agricultural problems. Emphasis will be placed on agricultural problems. Emphasis will be placed on food processes and environmental systems.

APPROACH: Although the approach to be used in this work differs somewhat from problem to problem, it usually involves the following steps: Definition of a performance criterion or objective for the processing system. Development of a mathematical model to describe the processing system. Application of optimization techniques to develop optimal solutions. Analysis of results.

PROGRESS: The first phase of this research is primarily concerned with the development of systems for the treatment and utilization of livestock and agricultural wastes as alternate sources of animal feed, energy and fertilizer. These investigations are specifically concerned with: The development of physical-chemical processes for recovering undigested grain, fibrous residue and protein from livestock wasted; The incorporation of naturally-occurring biological processes in the treatment of livestock wastes and the production of energy (methane gas), fertilizer and animal feeds (Single-cell protein), and finally, An assessment of its technological impact on the environment and socio-economic structure. In the second phase of this research, a new sorption kinetic model was developed based on simultaneous adsorbed-phase diffusion and internal surface adsorption inside a particle. The resulting equation did an excellent job of fitting experimental kinetic data for the sorption of water vapor into corn, and the sorption of carbon tetrachloride vapor into wheat. The resulting model parameters were physically significant which indicates that the proposed mechanism is realistic and that the model equation has considerable value for use in analysis and design of fumigation and aeration processes.

SUPPORTED BY Kansas State Government

2.0099,

STUDY OF INTERMEDIARY METABOLISM OF RUMEN MICROORGANISMS IN MIXED AND PURE CULTURE

L.R. Fina, Kansas State University, Agricultural Experiment Station, Dept. of Biology, *Anderson Hall, Manhattan, Kansas* 66502 (KAN00641)

OBJECTIVE: Determine: the rumen degradation of alfalfa-C in situ and with the aid of an in vivo artificial rumen, the formation of rumen fermentation compounds and their assimilation, the mechanism of methane production from organic compounds found in the rumen.

APPROACH: Alfalfa-C (prepared at the Kansas Station) will be placed in the rumen in situ and in the in vivo artifical rumen. The decomposition of alfalfa and the production of individual VFA will be followed using column and paper chromatography and radio tracer techniques. The appearance of C in the blood, urine and feces will be determined to learn more about assimilation of rumen fermentation products. Pure cultures of rumen bacteria and protoza will be grown in the in vivo environment using the in vivo artificial rumen apparatus. This method will be used to cultivate fastidious rumen bacteria which have heretofore been impossible to grow in pure culture.

PROGRESS: It was reported last year that cell-free and bacterial cell-bound lipopolysaccharide (LPS) endotoxin was found in large amounts in cattle fed grain rations. The amounts in hay fed cattle was at least one-half to one-third as great. Work to be reported at this time verifies this (see publication). There is a definite toxic effect on cattle of endotoxin or LPS. Milligram quantities injected into the jugular vein of cattle causes a severe reaction and death. It is postulated that the endotoxin is absorped into the thoraic duct through breaks in the ruminal epithelium. All lymphatics find their way to the thoraic duct which empties into the anterior venacava. Work is in progress using chromium 51 labeled endotoxin to trace the path of the LPS. Work is continued on the anaerobic rupture of benzoic acid during methane fermentation. Two papers have been prepared and submitted for publication in Archives for Microbiology. No new results to be reported at this time.

SUPPERTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Kansas

2.0100,

HARDWOOD SPECIES AND CULTURAL PRACTICES NEEDED FOR RAPID FIBER PRODUCTION

W.A. Geyer, Kansas State University, Agricultural Experiment Station, McIntire Stennis Program, *Anderson Hall, Manhattan, Kansas* 66502 (KAN00770)

OBJECTIVE: Development of streamside sites for wood fiber production utilizing rapid growing hardwoods and intensive silvicultural practices: (1) Selection of tree species for rapid growth rate, tree form, and wood quality. (2) Determine resprouting ability. (3) Develop optimum spacing and cultural techniques.

APPROACH: Native and non-native species, cottonwood varieties, and hybrid-poplars will be secured; stressing types adapted to plains conditions from superior trees. Initial collections and additions will be outplanted at basic spacings of 2 x 2, 3 x 3, and 4 x 4 feet to supply early evaluations of factors listed under objective 1. Separate plantings will be made to determine sprouting ability and quality following continuous annual cuts. Desirable selections from initial plantings will be tested at spacings convenient for mechanical handling. Weed control, fertilizer applications, and irrigation will be investigated.

PROGRESS: A major objective of this study was to determine above ground biomass yield of short rotation coppicing hardwood species over period of years. Silver maple has great potential for producing fiber rapidly and was thus one of the early species tested (earlier results presented as phase 1 in the annual reports). Field tested 10 years, silver maple appears to be desirable for short rotation rapid fiber production, such as 'energy forests.' Data were compiled after 8 years growth on a good silty clay loam alluvial site in eastern Kansas. This information is being published in the USFS 'Tree Planters Notes.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Kansas

2.0101,

CONDUCTING A DEMONSTRATION AS TO THE PRACTICALITY OF AN ENERGY FOREST AS A FUEL RESOURCE FOR THE UNIVERSITY

W.A. Geyer, Kansas State University, Agricultural Experiment Station, Dept. of Horticulture & Forestry, *Anderson Hall, Manhattan, Kansas* 66502 (KAN-05-496)

OBJECTIVE: Determine the optimum sources of wood fuel to meet the energy demands of theUniversity of Kansas steam generating plant.

APPROACH: Establish rapid fiber test plantations at representative sites in the Lawrence area for biological and energy yield, plus economic analysis. Evaluate various forms of wood fuel foravailability, handlings, processing, and storage. Conduct an urban 'waste'wood and sawmill residue survey.

PROGRESS: Three sites have been selected for plantation development in the Lawrence vicinity. The Clinton Reservoir site is alluvial soil of heavy silt loam. The Sunflower Research Center is gently rolling prairie upland soil - loamy topsoil over clay loam subsoil. A 3-step planting program is being followed: 1) spacing trials using Nelder's variable spacing 'cartwheel' design; 2) medium-sized plots trials (1/5th acre at 4'x4' spacing for maching cutting trials, weed control or fertilization; 3) wide-row trials (9 or 10 feet) utilizing contemporary equipment. Plantations were established at the Clinton and Sunflower sites during May. The Kaw Valley site will be planted this coming April. Two-acre test plots were established containing 5 'cartwheel' spacing subplots on a 51.6 ft. radius, 30 spokes/circle, 7 trees/spoke (210 trees/circle). Each cartwheel contains a different species - cottonwood, silver maple, black locust, Siberian elm, and European black alder. The other 1/2 of the 2-acre plot contains linear planting at 4'x4' spacing - 10 rows by 140 rows.

SUPPORTED BY Kansas State Government

2.0102,

GREAT PLAINS ENERGY FOREST STUDY

W.A. Geyer, Kansas State University, Agricultural Experiment Station, Dept. of Forestry, *Anderson Hall, Manhattan, Kansas* 66502 (KAN-05-620)

OBJECTIVE: Develop a short rotation silviculture system to produce fuel wood from woody biomass: Determine productivity of coppicing hardwood trees, determine financial and energy costs, evaluate effectiveness of herbicides for weed control.

APPROACH: Establish study plots using 'Nelder' circular design to test species, spacing, and weed control difference in productivity.

SUPPORTED BY Kansas State Government

2.0103,

ANIMAL WASTE MANAGEMENT SYSTEMS FOR THE 1980'S

R.I. Lipper, Kansas State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Anderson Hall, Manhattan, Kansas* 66502 (KAN00778)

OBJECTIVE: Develop optimal manure management systems for animals in confinement housing. Investigate systems of manure management for production of methane and conservation of plant nutrients.

APPROACH: Develop design criteria, make field trials and evaluate performance of flushing gutter manure transport systems and components for livestock confinement facilities with emphasis on swine. Continue investigation of methane production from anaerobic digestion of swine manure with special reference to the role played by ammonia in the bacterial decomposition of undiluted wastes to methods of scrubbing ammonia and CO(2) from digester gases and capturing ammonia for later use as fertilizer. Measure pollution potential of stormwater and irrigation runoff from corn fields where feedlot manure has been incorporated into the soil at rates ranging from 0 to 300 dry tons per acre per year and develop a suitable field sampler for stormwater runoff.

PROGRESS: Automatic or semi-automatic systems for disposing of animal waste slurries onto land made it possible to dispose of waste at frequent intervals. Systems that dispose at frequent intervals with low labor requirement could reduce the size of slurry storages and the amount of stored wastes that produce objectionable odors. Commercially available units using big gun sprinklers could be adapted to such systems but their disposal rate is too high for most producers. High volume (300 gpm or more) is and inherent characteristic since minimum nozzle size and pressure dictate minimum flow rate. We are developing slurry spinner similar to spinners used to distribute dry fertilizers that we hope would spread when pumping rate of slurries containing manure solids is as low as 20 or 30 gpm. A prototype spinner has been designed and built as is ready for testing.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Kansas

2.0104,

ENERGY RELATED TECHNOLOGICAL DEVELOPMENT

W.P. Walawender, Kansas State University, Agricultural Experiment Station, Dept. of Chemical Engin, *Anderson Hall, Manhattan, Kansas* 66502 (KAN00946)

OBJECTIVE: This project is directed at development of a continuous pryolysis pilot plant facility for the recovery of useful products from animal wastes. Produce a synthesis gas (composed primarily of CO, H(2), CO(2) and CH(4)) from feedlot manure.

APPROACH: The development involves low pressure flash pyrolysis in a fluidized bed designed to maximize both gas yield and quality.

PROGRESS: 1) Protolysis Modeling - Modeling of reaction in a fluidized bed with constant properties have also been completed. The results demonstrate the influence of minimum fluidization velocity, superficial velocity, distributor design, and bed height on conversion. This model has also been extended to the case where bed properties vary with height. 2) Measurement of Solids Velocity - Fiber optics are being used to measure reflected light from moving solid particles. The resulting signal can be processed in a minicomputer to evaluate the particle velocity. Excellent results are obtained for constant velocity, but the variable velocity case is more difficult to treat. Correlation techniques are being developed to permit velocity measurement for this case. 3) Cold bed studies - Data for solids transfer have been qualitatively explained in terms of density differences as the driving force for transfer in the parallel bed system. Design modifications have been made to permit minimum density at the transfer line exit and maximum density in the transfer line. These conditions provide maximum transfer rate with minimum gas leakage. In addition the results of this work provide for identification of the key factors to control the transfer rate. 4) Solids feeding - Efforts in this area have been directed at examination of design modifications (screw type and exit geometry) and their influence on stability of the feed stream for atmospheric discharge.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Kansas

2.0105,

CHEMICAL PROCESSING OF FEEDLOT MANURE

L.T. Fan, Kansas State University, School of Engineering, Dept. of Chemical Engin, *Anderson Hall, Manhattan, Kansas* 66502

Description: The economic feasibility and potential applications for producing synthesis gas (a mixture of CO and H(2) from cattle feedlot manure via fluidized bed pyrolysis was studied. An estimated 10.7 million standard cubic feet per day of synthesis gas could be produced by the conceptual design plant at a cost, including profit, of $0.85 per thousand standard cubic feet. Sensitivity analysis showed that production costs of the gas was affected by changes in plant capacity, incoming manure moisture content, and the cost of transportating manure from feedlots to the plant. Changes in chemical composition of the dry, ash-free manure had little effect on gas production costs. Based on the economic analysis and a survey of feedlot capacities in southwestern Kansas, the potential application of manure pyrolysis was studied. Plants processing up to 4.125 tons per day of dry manure could be supported with the cost of producing synthesis gas about $0.50 per thousand standard cubic feet. The gas could be used as a raw material and energy source for making up to 346,500 tons per year of ammonia or could be used to run electricity generating plants at up to 325 megawatts. The fluidized bed simulation unit was used to study elutriation of sand, manure, and ash particles in addition to observing the general operating characteristics of the bed. Both batch and continuous feeding experiments were conducted. Experimental elutriation rates were higher than predicted from existing correlations. The differences were explained by inaccuracies inherent in the correlations. The results were used to estimate ash build-up in the solids for a pilot scale gasifer which was found to be minimal.

Bibliographic references: Engler, C.R.; W.P. Walawender, L.T. Fan, 'The Potential of Manure Pyrolysis for Ammonia Production and Electric Power Generation in Kansas,' Report #61, Institute for Systems Design Optimization, Kansas State University, Manhattan, KS, September 1974.

Addenda: Estimated calendar year funding reported as 1974 $10,000, 1975 $25,000.

SUPPORTED BY Kansas State Government

2.0106,

PRODUCTION OF METHANE GAS

L.T. Fan, Kansas State University, School of Engineering, Dept. of Chemical Engin, *Anderson Hall, Manhattan, Kansas* 66502

DESCRIPTION: The first phase of this research is primarily concerned with the development of systems for the treatment and utilization of livestock and agricultural wastes as alternate sources of animal feed, energy and fertilizer. These investigations are specifically concerned with: (a) The development of physical-chemical processes for recovering undigested grain, fibrous residue and protein from livestock wastes; (b) The incorporation of naturally-occurring biological processes in the treatment of livestock wastes and the production of energy (methane gas), fertilizer and animal feeds (Single-cell protein), and finally, (c) An assessment of its technological impact on the environment and socio-economic structure. In the second phase of this research, a new sorption kinetic model was developed based on simultaneous adsorbed-phase diffusion and internal surface adsorption inside a particle. The resulting equation did an excellent job of fitting experimental kinetic data for the sorption of water vapor into corn, and the sorption of carbon tetrachloride vapor into wheat. The resulting model parameters were physically significant which indicates that the proposed mechanism is realistic and that the model equation has considerable use in analysis and design in fumigation and aeration process.

ADDENDA: Estimated calendar year funding reported as 1974 $6,000, 1975 $6,000.

SUPPORTED BY Kansas State Government

2.0107,

ENERGY REQUIREMENTS FOR OPERATING COMMERCIAL CATTLE FEEDLOTS

R.I. Lipper, Kansas State University, School of Engineering, Dept. of Agricultural Engineering, *Anderson Hall, Manhattan, Kansas* 66502 (KAN-05-384)

OBJECTIVE: Determine, define, categorize and quantify the energy uses within the physical confines of commercial cattle feedlots in Kansas for determining whether or not or to what extent the energy requirements of such feedlots may be met by utilizing the animal wastes as an energy source.

APPROACH: Data gathered will be obtained by on-site surveys of feedlots that will provide access to records and that have adequate records to provide sufficiently detailed information. Where information available is insufficient in specific categories, on-site observations combined with engineering estimates will be used to classify, categorize and quantify data. Feedlots studied will be those that prepare dry grains by steam rolling, grinding or other and those that ensile wet grains, ground or whole, for feeding without other extensive processing. Three feedlots in each of the above two categories will be studied. Feedlots will be selected that represent a cross section of the commercial cattle feeding industry in Kansas.

PROGRESS: Interviews and on-site observation at 11 commercial cattle feedlots in Kansas provided data on use of diesel fuel, gasoline, natural gas, LP gas, and electricity for feed processing, feed handling, livestock watering, illumination, waste removal, administration, branding, and thawing, space heating, and miscellaneous. The survey covered 30% of Kansas feedlots with capacities from 8,000 to 16,000 head and 20% of those over 16,000 head for a total of 25 feedlot-years of data. Feed processing methods (steam flake, 'miconizing', dry roll, or ensiled) was responsible for the greatest variation in energy use.

SUPPORTED BY Kansas State Government

2.0108,

PYROLYSIS OF FEEDLOT MANURE

W.P. Walawender, Kansas State University, School of Engineering, Dept. of Chemical Engin, *Anderson Hall, Manhattan, Kansas* 66502

Effects of distributor designs and bed internals (via. Koch mixers) on solid transfer rates in the parallel bed gasifier were examined. No pronounced advantages of using internals was found. In some cases, internals even reduced the transfer rates. Distributors of asymmetric design gave significantly better solid transfer rates than those of symmetric design. The best results obtained so far showed a five-fold increase.

Gas leakage through transfer lines in the parallel bed gasifier was measured. A CO2 (as tracer gas) and air mixture of known concentration was fed to upstream of one bed while only air was fed to the other. Gas samples at downstreams of both beds were withdrawn and analyzed. Although some refinement is needed to give more accurate figures, rough estimations from data of two runs gave a gas leakage range of 3.-19.% of the total gas rate in one column.

A transient analysis applicable to a general pyrolysis reaction system was developed as a pyrolysis reaction model. Variations of void fraction and apparent transport properties as functions of thermal degradation were considered. The volume reaction model was employed for calculation. Effects of various parameters, i.e., initial fluid and solid concentrations, Thiele modulus and Lewis number on the fluid and solid concentration distributions, and the solid conversion under non-isothermal conditions were numerically determined.

A review of feeders for conveying dry manure to the fluidized bed pyrolizer was conducted. Among these, attention was focused on the screw feeder, rotary feeder, fluidized bed feeder and combinations of them. An experimental study was carried out to examine the performance of the screw feeder. The results indicate that manure feed is a strong function of size distribution and moisture content of the manure.

BIBLIOGRAPHIC REFERENCES: Chen, T. Y., E. Kojima, W. P. Walawender & L. T. Fans, 'A Review of Waste Gasification Technology as Developed in Japan,' Report #68, Institute for Systems Design and Optimization, December 17 (1975). Engler, C. R., W. P. Walawender & L. T. Fan, 'Synthesis Gas from Feedlot Manure,' Environmental Science & Technology, December (1975).

SUPPORTED BY Kansas State Government

2.0109,

DISPOSAL OF FEEDLOT WASTES USING A TWO-STAGE OXIDATION PROCESS WITH NET ENERGY PRODUCTION

H. Rosson, University of Kansas, Lawrence Campus, School of Engineering, Dept. of Chemical & Petroleum Engin, *Learned Hall, Lawrence, Kansas* 66044

Description: Feedlot waste disposal process in which the energy content of livestock manure is used directly for power production is attractive, compared to indirect processes such as synthetic fuel conversion, in that it could be simpler and more efficient with favorable economics less dependent on the scale of operation. The objectives of the proposed research are: (1) the determination of the feasibility of the Zimmerman wet oxidation process as part of a direct-fire disposal method for producing net useful energy from wet, undried manure; (2) the determination of the suitablity of other sludge burning processes such as multiple hearth or fluidized bed incineration for use as a secondary step to complete the oxidation reaction; and (3) the development of a preliminary engineering design for the overall process. Successful completion of the proposed research could provide a solution to the problem of manure disposal and also could provide a method for converting an undesirable pollutant into a supplemental energy resource.

Addenda: Estimated calendar year funding reported as 1975 $8,000.

SUPPORTED BY University of Kansas

2.0110,

MANAGEMENT OF AMERICAN SYCAMORE (PLATANUS OCCIDENTALIS L.) ON SHORT COPPICE ROTATIONS

R.F. Wittwer, University of Kentucky, Agricultural Experiment Station, Dept. of Forestry, *Limestone & Euclid, Lexington, Kentucky* 40506 (KY00619)

OBJECTIVE: Evaluate influence of spacing, fertility, and rotation age on production of above-ground biomass on different sites. Determine the uptake, distribution and possible removals of nutrient elements in the above-ground biomass.

APPROACH: Total above-ground biomass production of coppice growth on young, closely-spaced platanus occidentalis L. Plantations established on different sites at various spacings, subjected to various fertilizer treatments and harvested at various rotation ages will be measured. Nutrient uptake and distribution in the biomass will be determined. Results will be analyzed to develop systems for maximizing production of cellulose.

PROGRESS: Three-year-old coppice plots of american sycamore were harvested to determine weight yields for various spacing (1'x3', 3'x3', 6'x3') and fertilizer treatments (none, 150 lbs N/acre, 150 lbs N/acre plus 100 lbs P/acre) on two sites. The sites under study are a bottomland, floodplain soil of the ashton series and a terrace soil of the otwell series, both in the Ohio River Valley. Production was highest on the closely spaced plots and declined with increased spacing. There were no large differences between the plots receiving N and P and those receiving only N. The fertilized plots produced approximately 50 to 275% more biomass than the unfertilized plots depending on the specific spacing, site and fertilizer treatment. Production averaged over both sites and all treatment combinations was approximately 18.6 tons/acre or 6.2/tons/acre/year or approximately double that for the 3-year-old seedlings initially harvested on these plots.

SUPPORTED BY Kentucky State Government

2.0111,

MOISTURE CONTENT AND DIMENSIONAL STABILITY OF SOUTHERN WOODS IN GREEN AND SERVICE CONDITION

E.T. Choong, Louisiana State University, Agricultural & Mechanical College, Agricultural Experiment Station, *University Station, Baton Rouge, Louisiana* 70803 (LAB01434)

OBJECTIVE: Determine the seasonal variations of green moisture content in standing trees and in freshly cut logs. Determine the variations of moisture equilibrium and dimensional change property, of various woods with respect to specific gravity variations under controlled conditions. Ascertain dimensional changes in wood subjected to different cycles of humidities. Understand more about the mechanism of dimensional change property of wood.

APPROACH: Measure green moisture content in standing trees and logs of various southern woods at different times of the year. Determine equilibrium moisture content and change in dimension of these woods at various humidity conditions and drying conditions. Also, determine specific gravity of dry cell wall pycnometrically using water displacement technique and specific gravity of the cell wall substance in the green volume by optical methods. analyze shrinkage as functions of specific gravity of whole wood and wood substance.

PROGRESS: A number of hardwood species growing at the Idlewild Plantation were selected for determination of green moisture content at dbh. Increment core sampling was done at periodic interval of about once every three months to determine the effect of seasonal variations on tree moisture in several tissues (bark, sapwood, and heartwood). Data are currently being analyzed. The fuel values, moisture content, and density of fresh and piled hardwood residues from several sawmills in southeast Louisiana were studied. The results show that moisture content of the residue has a profound effect on the heat value, i.e. the heat value decreasing sharply with an increase in moisture content. Nevertheless, at an average moisture of 107% for sawdust and bark residue, the total fuel content of this residue was calculated to be 4.7 x 10' BTU for the study area, which is equivalent to 3.7 million gallons of No. 6 oil per year--enough heat energy to kiln dry 65 million board feet of hardwood lumber from about 47 to 7% moisture content. The hygroscopic properties of sapwood and corewood from 22 species of southern hardwoods were examined. Differences among species are found predominantely at higher humidities. The analysis of individual species indicated that

the EMC of corewood sometimes averaged significantly less than that of sapwood.
SUPPORTED BY Louisiana State Government

2.0112,

ENGINEERING SYSTEMS FOR MANAGEMENT AND USE OF ENERGY FROM BIOMASS

B.J. Cochran, Louisiana State University, Agricultural & Mechanical College, Agricultural Experiment Station, Dept. of Agricultural Engineering, *University Station, Baton Rouge, Louisiana* 70803 (LAB01952)

OBJECTIVE: Determine the feasibility of designing and constructing an on-farm fuel generator using biomass material as an energy source. Determine alternate means of utilizing agricultural products as sources of energy. Characterize and improve energy management strategies for environmentally and economically acceptable crop productiCn systems.

APPROACH: Investigate the various processes known for producing fuels from biomass materials. The processes determined most feasible for farm size generators will be thoroughly evaluated using biomass materials to produce fuels. The types of materials such as crops, weeds, grasses and animal waste, capable of being converted into fuels will be determined. Fuels produced from biomass will be tested for use in internal combustion engines heating buildings and crop drying. Methods of storing fuels on the farm will be considered. Evaluate methods through systems analysis for reducing energy input to crop production. Each cropping operation will be evaluated with respect to all operations to determine the total energy effect of the operation. Techniques of utilizing some agricultural residues as energy for processing with respect to quality, management and cost will be studied. The feasibility of transporting some residue from the production area will be determined.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Louisiana

2.0113,

METHANE AND VOLATILE FATTY ACIDS FROM CHEMICALLY TREATED AGRICULTURAL RESIDUES

C.D. Callihan, Louisiana State University, Agricultural & Mechanical College, School of Engineering, Dept. of Chemical Engin, *University Station, Baton Rouge, Louisiana* 70803 (C624A-7050)

The objectives of this research are to produce methane and volatile fatty acids from alkali treated bagasse and other cellulose wastes. A process has been proposed that will be tested for continuous removal of intermediate organic acids formed in the anaerobic generation of methane.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Municipal Environmental Research Lab.

2.0114,

VARIATION IN PROPERTIES OF WOOD AND BARK OF SECOND-GROWTH SWEETGUM TREES

E.T. Choong, Louisiana State University, Agricultural & Mechanical College, School of Forestry & Wildlife Management, Mcintire Stennis Program, *University Station, Baton Rouge, Louisiana* 70803 (LAB01682)

OBJECTIVE: Compare selected anatomical, physical, and chemical properties of sweetgum wood and bark. Determine the variation of these properties within and among trees growing in a bottomland and an upland site. Characterize some of the extractives and minerals in wood and bark.

APPROACH: Obtain wood and bark samples from various heights in trees growing on bottomland site and upland site. Properties to be determined are: green moisture content, equilibrium moisture content, specific gravity, differential shrinkage, toughness, tissue content, dimensions and fibril angle of fiber tracheid, tension wood, interlocked grain, extractives content, mineral contents, pH, and heat of combustion. In addition, attempts will be made to isolate pure fractions of the phenolic compounds and identify them by comparison with known compounds chromatographically and spectrographically.

PROGRESS: The wood and bark of sweetgum were extracted with ethanol and fractionated for chromatographic examination. Individual components were then isolated and characterized by their R values, color reactions and spectral properties. Ellagic acid and galloc acid were both found in bark, and in sapwood and heartwood. Dihydroquercetin (taxifolin) was found in the sapwood, and there is strong evidence for quercetin in the heartwood; but these compounds were not major constituents of the bark. A mixture of methylated ellagic acids is suspected in the bark but could not be detected in either sapwood or heartwood. Preliminary work was done to determine the axial and lateral variations of specific gravity and fiber length on two sweetgum trees. Data are currently being analysed. Samples for studying wood characteristics are being collected from 3 trees each of six locations to encompass wide geographical areas in Louisiana, representing various bottomland (wet) and upland (dry) sites. The variations in specific gravity, fiber length, tissue types, cell dimension, green moisture content, and hygroscopicity within and between trees are being studied. Fuel values (in terms of BTU per M Bd. Ft. Doyle of wet material) and volumes for sweetgum bark compared favorably with several Delta hardwood barks obtained in two mills in Louisiana. The ultimate fuel values are dependent largely on log and bark storage conditions and processing methods.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Louisiana

2.0115,

REFUSE BURNING FOR ENERGY RECOVERY

R. Giglio, Central Maine Power Co., Dept. of Engineering, *Edison Dr., Augusta, Maine* 04336

Description: Investigations are being made of the technical and economic feasibility of using various types of refuse as a boiler fuel. Municipal refuse and wood industry wastes are being investigated for direct burning or conversion into a fuel.

SUPPORTED BY Central Maine Power Co.

2.0116,

MAINE FIREWOOD STUDY

J.W. Birkeland, Maine Audubon Society, *Portland, Maine*

Analyze to: (1) project firewood demand, (2) project available firewood supply, (3) determine the extent of present firewood operations, (4) determine the economic potential for a firewood industry, (5) examine the existing competitive hardwood uses, (6) examine existing firewood and (8) provide baseline marketing costs associated with a firewood industry.

SUPPORTED BY U.S. Dept. of Energy, Office of Fossil Energy

2.0117,

UTILIZATION OF AGRICULTURAL WASTES

R.J. Rowe, University of Maine, Orono Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *36 Winslow Hall, Orono, Maine* 04473 (ME06100)

OBJECTIVE: Investigate alternatives for constructive utilization of Maine's organic agricultural wastes.

APPROACH: Investigate anaerobic digestion, investigate algae culture for further waste treatment and as a food source for aquaculture systems. Investigate an integrated agriculture-aquaculture production system with waste recycling.

PROGRESS: Laboratory scale digesters were designed to study optimum conditions and kinetics for methane production. Fresh manure from caged layers was used. Sawdust was added in some treatments to simulate broiler droppings. The effects of temperature (78-120 F), solids concentration (1.5-18%), inoculum quantity (0.50%), and exogenous carbon sources (sawdust, potato wastes, etc.) on methane production were studied. Changes in volume and composition CH(4), CO(2), O(2), N(2), CO, and H(2)S) of gas produced were determined as function of time. Volatile acids, pH, and solids contents of fresh manure and digested effluent were measured. Solids content of 6.5-6.75% provided highest gas production, and methane content reached 87% for retention period of 30 days. 50-70% reduction in solids contents of completely digested effluents was achieved. Sawdust percentage used appeared to have very little effect. 600 gallon demonstration unit was designed and operated on batch basis, using results of laboratory scale digesters, in order to test control and feed mechanisms for future full-scale system application. The system overheated twice. Redesign of digestion unit and installation of control devices are taking place to ensure better unit performance and regulation.

SUPPORTED BY Maine State Government

2.0118,

STUDY OF SMALL SCALE WOOD COMBUSTION FOR SPACE HEATING

R.C. Hill, University of Maine, Orono Campus, Graduate School, Dept. of Industrial Cooperation, *36 Winslow Hall, Orono, Maine* 04473 (EC-77-S-02-4559)

Task 1: The contractor will construct a 100,000 Btu/hr, stick-wood fired furnace complete with water heat exchanger and storage tank. The unit will be similar in concept to the unit shown in Figure 3 of the proposal. The shape of the combustion space and the manner of introducing primary and secondary air will be flexible so that a broad performance data base can be generated. The goals of cost, efficiency, convenience and low emission will be articulated. Tests will be conducted to determine the effect of wood quality--specie, moisture, area-volume ratio, etc. The aim is to not only analyze the variables leading to design; but to develop a test chamber for possible subsequent work on small scale home or industrial combustion systems. Task 2: The data base will be extended as needed to provide a design and operation manual which will be prepared in photo-ready form for the government.

SUPPORTED BY U.S. Dept. of Energy

2.0119,

ANALYSIS OF MECHANIZED FOREST HARVESTING IN MAINE

T. Corcoran, University of Maine, Orono Campus, School of Forest Resources, Mcintire Stennis Program, *302 Boardman Hall, Orono, Maine* 04473 (ME05018)

OBJECTIVE: Classify various harvest/transport systems according to size, type of product, degree of mechanization, ownership, and geographical location. The classification to be used to find common trends in the systems. Develop conceptural designs for new or improved equipment, or recommendations for additional applications of present equipment.

APPROACH: Determine types of equipment in use; identify successful systems and sub-systems; identify improvements needed; develop design concepts for equipment to fulfill the needs.

PROGRESS: A survey of harvesting equipment and manpower utilization for 1974 in Maine and other parts of Northeastern U.S.A. has been initiated for action in January 1975. The survey instruments and techniques have been developed and data forms are currently being printed. This exploration has the active support of the major wood procurement firms and personnel from these firms have volunteered to be utilized in the data collection and assembly process. This will eliminate the need for costly survey techniques, provide for a near complete inventorying of the equipment categories of interest, and allow efficiency by enabling direct contact with those small and independent contractors and subcontractors who control a major share of the equipment and manpower in the study area. Preliminary studies have been made on the equipment and technique most suitable for retrieval of logging residues for use as fiber or fuel.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Maine

2.0120,

UTILIZATION OF LANDFILL METHANE WORKSHOPS

Unknown, Johns Hopkins University, Applied Physics Lab., *Johns Hopkins Rd., Laurel, Maryland* 20810 (P.R. M01-78-1048)

The objective of the project is to gather information on the technical, economic, and institutional issues surrounding the collection and utilization of landfill methane. A two-day workshop, tentatively scheduled for February 9 and 10, 1978, will be held to provide DOE with informed viewpoints about obtaining methane from sanitary landfills.

SUPPORTED BY U.S. Dept. of Energy, Div. of Buildings & Community Systems

2.0121,

BIOLOGICAL SOLAR ENERGY CONVERSION - APPROACHES TO OVERCOME YIELD, STABILITY AND PRODUCT LIMITATIONS

B. Kok, Martin Marietta Corp., Martin Marietta Laboratories, *1450 S. Rolling Rd., Baltimore, Maryland* 21227

This award is a sequel to NSF grant AER 73-03291. The overall objective is to assess the feasibility of using photosynthesis for producing energy-intensive

substances from renewable resources. The specific objective is to use the energy conversion system of green plants, divorced as much as possible from the other functions of the cell, to produce hydrogen and carbohydrates from carbon dioxide and water.

During this award period, an assessment will be made of the causes of loss of photosynthetic activity after isolation of chloroplasts from leaf cells, and of the differences in electron transport activities among chloroplasts isolated from different leaf tissues. In particular, the role of manganese ions in protecting chloroplasts from the attack of fatty acids, and the roles of the two photosystems in mesophyll and bundle sheath cells, will be studied.

SUPPORTED BY U.S. National Science Foundation, Div. of Problem Focused Research Applications

2.0122,

DEVELOPMENT OF EXTERNALLY HEATED ENGINES AND PUMPS

P.R. Payne, Payne Inc., *Annapolis, Maryland*

DESCRIPTION: An externally heated engine, employing a modified Rankine cycle, and in its simplest embodiment, having no moving parts. The basic engine is known as the 'water pulsejet'. Applicable to boat (ship) propulsion and water pumping in its simplest forms. For boat propulsion, predicted efficiency is comparable with a diesel driving a water propeller; cost is two orders of magnitude less. Small propulsion engines have already propelled small manned boats. 4 GPM irrigation suction pumps have been demonstrated, powered by open flame (propane, wood, agricultural refuse, etc.) Rate of progress is limited by the rate at which the company can fund the program without becoming insolvent. D.O.D. contracts are anticipated shortly.

BIBLIOGRAPHIC REFERENCES: 'An Engine With No Moving parts', by Peter R. Payne, Chemtech, January 1975. 'A New Steam Engine Cycle', by Peter R. Payne, 9th Intersociety Energy Conversion Engineering Conference - 1974 Proceedings.

ADDENDA: Estimated calendar year funding reported as 1975 $160,000. This project is also supported by: Payne Inc.

SUPPORTED BY U.S. Dept. of Defense, Unspecified Unit

2.0123,

WATER PULSEJET ENGINE AND PUMP

P.R. Payne, Payne Inc., *Annapolis, Maryland* (EG-77-C-01-4121)

An externally heated engine, employing a modified Rankine cycle, and in its simplest embodiment, having no moving parts. The basic engine is known as the water pulsejet. Applicable to boat (ship) propulsion and water pumping in its simplest forms. For boat propulsion, predicted efficiency is comparable with a diesel driving a water propeller; cost is two orders of magnitude less. Small propulsion engines have already been demonstrated, powered by open flame (propane, wood, agricultural refuse, etc.) Also has applications in transferring heat, as a heat pipe substitute. Transfer of 10 Kw over 8 feet by an 0.875 inch I.D. pipe has been demonstrated without any indication that this is near an upper limit for either heat loading or distance.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0124,

PHOTOCHEMICAL REACTIONS OF COMPLEX MOLECULES IN CONDENSED PHASE

H. Linschitz, Brandeis University, School of Arts & Sciences, Dept. of Chemistry, *415 South St., Waltham, Massachusetts* 02154

Elucidation of the sources of inefficiency in photoredox reactions involving electron or H-atom transfer to or from light-excited molecules. Laser flash photolysis and luminescence used to observe each stage of the overall redox process; reaction rates and products and intermediates yields allow identification of energy-storing and energy dissipating processes. Correlations made with solvent structure and polarity, redox potentials, and nature of excited states. Test substances include metalloporphyrins, including chlorophyll, and aromatic ketones. (DOE/ER-0002)

SUPPORTED BY U.S. Dept. of Energy, Office of Energy Research

2.0125,

ENGINEERING EVALUATION OF PROGRAMS TO RECOVER FUEL GAS FROM WASTE

D.L. Wise, Dynatech Research & Development Co., *99 Erie St., Cambridge, Massachusetts* 02139 (E(11-1)-2991)

Biomass resources such as algae, trees, kelp, agricultural crops, plant wastes, and animal manure can be digested to form methane sufficiently readily to supply significant quantities of fuel gas. Selecting the most practical biomass and designing processes for fuel production should result from research and development now underway at number of institutions. However, these investigators have different frames of reference and will present their results in formats that are not directly comparable. This project will coordinate these other groups by assisting in information exchange, evaluating engineering designs, criticizing systems analyses, and reducing economic analyses to a common set of assumptions and bases to facilitate comparisons. This overview will help identify areas in which additional or more accurate data are required so that the assessment of methane production from biomass is complete and reliable. (ERDA 76-137)

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0126,

PILOT SCALE PYROLYTIC CONVERSION OF MIXED WASTE TO FUEL

J. Porter, Energy Resources Co. Inc., *185 Alewife Brook Pkwy., Cambridge, Massachusetts* 02138 (B624B-399)

OBJECTIVES: To develop models relating fraction of fuel products (gas, liquid, solid) produced in pyrolysis of various types of solid wastes as function of pyrolyzed conditions. Solid wastes include mixed municipal, agricultural, and industrial wastes. An investigation of chemical conversions including steam gasification, partial oxidation, and catalytic effects of bed materials, as well as detailed analysis and characterization of pyrolysis products including char and oil, will be conducted.

APPROACH: Experimental study using small batch pyrolyzer and pilot size (200 kg/hr) fluidized bed pyrolyzer to produce data for model development and verification. Statistical and semi-empirical models will be examined for the normal fluidized bed pyrolytic reaction as well as for steam gasification and partial oxidation. Several char and oil samples will be analyzed in detail to evaluate the acceptability of fuel products.

STATUS: Fabrication of the test units is completed. Test runs are underway to accumulate data for model verification.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Industrial Environmental Research Lab.

2.0127,

ENZYMATIC SACCHARIFICATION OF CELLULOSE TO PRODUCE CHEMICALS AND LIQUID FUELS

M. Mandels, U.S. Dept. of Defense, Army, Natick Research & Development Command, *Natick, Massachusetts* 01760

TO CARRY OUT LABORATORY RESEARCH ON CELLULASE PRODUCTION AND SACCHARIFICATION OF WASTE CELLULOSE BY CELLULASE THAT WILL LAY THE FOUNDATION AND DEFINE THE PARAMETERS FOR A PRACTICAL PROCESS.

INVESTIGATE THE PHYSIOLOGICAL, BIOCHEMICAL, AND GENETIC FACTORS INVOLVED IN INDUCTION, SYNTHESIS, AND SECRETION OF THE ENZYME-UTILIZE THIS INFORMATION TO MAXIMIZE CELLULASE YIELDS- STUDY THE INTERACTIONS OF THE CELLULASE ENZYMES WITH THEIR SUBSTRATES, INCLUDING THE EFFECTS OF LEVELS OF THE VARIOUS ENZYME COMPONENTS, EFFECTS OF INHIBITORS INCLUDING THE PRODUCTS OF THE REACTION, AND THE EFFECTS OF CELLULOSE STRUCTURE, DEGREE OF CRYSTALLINITY, AND ADMIXTURE WITH IMPURITIES SUCH AS LIGNIN ON THE RATE AND EXTENT OF THE HYDROLYSIS REACTION- AND UTILIZE THIS INFORMATION TO MAXIMIZE SUGAR YIELDS.

SUPPORTED BY U.S. Dept. of Defense, Army, Natick Research & Development Command

2.0128,

WOOD RESIDUES AS FUEL STOCK FOR WOOD GAS GENERATORS

W.W. Rice, University of Massachusetts, Amherst Campus, Agricultural Experiment Station, Mcintire Stennis Program, *Amherst, Massachusetts* 01002 (MAS00026)

OBJECTIVE: Characterize residues available for fuel in terms of quantity, source, variability, form, bulk density, moisture and BTU content. Develop cost-performance data. Develop material specifications.

APPROACH: Research is divided into discrete units based on source and differences in factors affecting efficiency of use of residues -forest residues, mill residues, urban waste.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Massachusetts

2.0129,

FUEL GAS PRODUCTION FROM MUNICIPAL SOLID WASTE

E.E. Lindsey, University of Massachusetts, Amherst Campus, School of Engineering, Dept. of Chemical Engin, *Amherst, Massachusetts* 01002

DESCRIPTION: 1. Kinetic studies on anaerobic digestion of solid waste as an aid to design using radioactive carbon-14 tagged acetic acid to obtain rate data for the methane formation step. 2. Use of ATP assay by rapid bioluminescent reaction as an 'on line' indication of digester activity. Adenosine triphosphate (ATP) is an intermediate in cell metabolism and its amount may be an indicator of biomass activity. The 'firefly' reaction of ATP with the enzymes luceferin and luciferase gives a brief flash of light, which is photometrically measurable and correlates with ATP. Difficulties with technique have been resolved and one test shows some correspondence of ATP with methane production. 3. Use of froth flotation as a means of microorganism separation and recycle to improve digester performance. Substantial cost savings through reduced digester volume are possible if its bacterial populations can be built up through recycle, i.e., if they can be separated from the mass which remains after digestion and must be discharged. We have begun a careful surface chemistry investigation of the removal of bacteria in a froth formed from part of the gases produced first in pure cultures, next in digested sewage sludge, finally in digested solid waste. 4. Cost analyses of various parts of the biochemical fuel gas production from solid waste (such as CO(2) removal) have been made for Dynatech. 5. Study of the variables affecting digester operation in the mesophyllic range.

ADDENDA: Estimated calendar year funding reported as 1975 $23,000. This project is also supported by: Dynatech Corp.

SUPPORTED BY University of Massachusetts

2.0130,

CULTIVATION OF MACROSCOPIC MARINE ALGAE FOR ENERGY CONVERSION, HYDROCOLLOID PRODUCTION, AND ADVANCED WASTEWATER TREATMENT

J. Ryther, Woods Hole Oceanographic Inst., *Main St., Woods Hole, Massachusetts* 02543 (E(11-1)-2948)

Screening of various species of marine macroscopic algae obtained from the East and West Coast of the U.S. will be done utilizing 10-liter culturing units. The screening tests will evaluate growth rate, caloric value, hydrocolloid content, nutrient uptake capacity, amenability to growth in suspended culture, persistence of vegetative growth phase and resistance to epiphytization. The more promising algae will be studied further in outdoor culturing facilities now in existence. These larger scale culturing units (on the order of several thousand gallons each) will be operated on mixtures of sea water and secondary effluent; parallel tests will utilize sea water plus chemical nutrients instead of sewage effluent. During this phase, data will be obtained pertaining to optimum standing biomass levels, biomass harvesting frequency, nutrient flow, trace metal metabolism, control of epiphytization, and control of predation losses.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0131,

CULTIVATION OF MACROSCOPIC MARINE ALGAE FOR ENERGY CONVERSION, HYDROCOLLOID PRODUCTION, AND ADVANCED WASTEWATER TREATMENT

J. Ryther, Woods Hole Oceanographic Inst., *Main St., Woods Hole, Massachusetts* 02543 (E(11-1)-2948)

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SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0132,

CATALYTIC CONVERSION OF MUNICIPAL SOLID WASTE, CELLULOSICS, AND BITUMENS TO OIL AND HIGH BTU GAS

A.H. Weiss, Worcester Polytechnic Inst., School of Chemical Engineering, Dept. of Chemical Engin, *Worcester, Massachusetts* 01609

Description: The basis for a practical and economic process to convert solid waste to oil has been established under EPA Grant R-EP-00516-02. It has been found that at approximately 800 degrees F, 100 psig, in the presence of nickel and cobalt catalysts, powdered newspaper can be continuously hydrogenated to oil containing 0-5% oxygen. The newspaper, a model feed for solid waste, is slurried into an oil carrier and pumped into a continuously stirred tank reactor (CSTR) where 85% of higher conversion, without plugging resulting from the transition from solid to liquid, occurs. Reaction conditions in the CSTR are such that approximately half of the hydrogen needed is produced in situ and approximately 2-1/4 barrels (99 gallons) of low sulfur oil are produced per ton of solid waste organics. It is projected that the process can break even at the 500 ton/day solid waste level, if the oil is valued at $8.00/Bbl. Basic research has established the kinetics and mechanisms for the process and shown that the process is also applicable for high BTU gas synthesis. Not only cellulosics, but also peat, shale, and coals can be converted.

Addenda: Estimated calendar year funding reported as 1974 $60,000, 1975 $125,000.

SUPPORTED BY U.S. Environmental Protection Agency, Unspecified Unit

2.0133,

PROCESS EVALUATION - CHINA LAKE PYROLYSIS SYSTEM

M. Zeitoun, Dow Chemical Co., *220 Dow Ctr., Midland, Michigan* 48640 (B624B-T73)

This task calls for a complete environmental, economic, and technical feasibility study of a pyrolysis, gas cleaning, and thermal polymerization process (taking waste all the way to gasoline) developed at the Naval Weapons Research Center, at China Lake, California.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Industrial Environmental Research Lab.

2.0134,

ANIMAL WASTE MANAGEMENT SYSTEMS FOR THE 1980'S

J.B. Gerrish, Michigan State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *New Administration Bldg., East Lansing, Michigan* 48823 (MICL01066)

OBJECTIVE: Develop optimal animal manure management systems. Characterize atmospheric contaminants and develop abatement methods to eliminate the contaminants' potentially harmful effects on human and animal health. Investigate use of by-products of animal manure management systems for energy sources, feed ingredients, plant-nutrients and other potential uses. Characterize the non-point pollution water runoff sources from livestock and poultry enterprises on pasture production systems and land areas with manure application and to further develop guidelines for abatement of non-point pollution sources from animal manures.

APPROACH: Study hydraulic transport of manure as practiced in flushing systems. This will lead to design recommendations and workable plans. Modelling studies are already well underway. In odor control, we are studying the effects of ozone on swine waste. Also studying the culture of purple sulfur bacteria as an odor modifier in anaerobic lagoons. Hope to develop procedures to foster such a culture under Michigan climatic conditions. Studying liquid-solid separation for its potential as a step in a fermentation process leading to a re-fed product. Have two year's data from some spring-thaw runoff events at system of 12 plots where manure was applied on the frozen ground. This study will continue in an attempt to develop control strategies which would minimize non-point source pollution. (20% basic research; 60% applied research; 20% development effort).

PROGRESS: The small scale model flushing system has been verified for its ability to transport standard-size particles. The feces-like particles are moved distances which correspond to distances moved in the prototype barn. A full-scale fiberglass stopless tank was constructed and installed in the MSU swine finishing barn. The tank height can be varied to further test the model. Our work with purple sulfer bacteria continues: we have surveyed some 25 lagoons in five states and determined that for these bacteria iron is never a limiting nutrient in swine waste lagoons. Light penetration and temperature are probably the dominant limitation to open cultures in the northern states. Liquid solid separation of swine waste can be enhanced by removal of fine particles in a pre-wash operation. The remaining solids dewater readily.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Michigan

2.0135,

ECONOMICS OF ANIMAL WASTE MANAGEMENT AND ENVIRONMENTAL QUALITY

J. Johnson, Michigan State University, Agricultural Experiment Station, Dept. of Agricultural Econ, *New Administration Bldg., East Lansing, Michigan* 48823 (NRE-41-302-26-01)

OBJECTIVE: Evaluate the economic impact on livestock farmers, consumers, processors, marketing firms, and taxpayers of proposed and potential guidelines; evaluate alternative animal waste systems; and determine least-cost abatement practices.

APPROACH: The cattle feeding, dairy, hog, and poultry portions of the livestock industry will be studied. First, attention will focus on the economic impact of proposed point source effluent limitation guidelines. Secondly, the economic impact of alternative measures and guidelines relating to the control of nonpoint sources of animal waste will be analyzed. The basic analytical approach will be a series of partial equilibrium analyses employing budgeting and linear programming techniques.

PROGRESS: Over one-fifth of all farms producing hogs in the 15 major hog-producing states were estimated to have runoff problems. The impact of runoff control would fall more heavily on small producers. Farms selling fewer than 100 hogs annually would incur investments of about $61 per hog and additional annual costs of $4.24 per 100 pounds of hogs sold. Farms with output above 1,000 hogs would require $4.00 investment per hogs and $0.26 of additional operating costs per 100 pounds. However, after adjustments to comply with environmental regulations are completed, pork will be little or no more expensive to the consumer. Feedlots of over 2,000 head capacity accounted for 58 percent of all feed cattle marketing in the U.S. in 1973. Fifty-six percent of the feedlots spread manure on land that they operate. The average application rate was 18 tons per acre. The value of gas (fuel) and sludge (fertilizer) from anaerobic production of methane from animal waste is expected to exceed annual costs if the output can be fully used. Michigan feedlots would adjust to pollution abatement controls by modest reductions in beef output.

SUPPORTED BY U.S. Dept. of Agriculture, Economics Statistics & Cooperatives Service, Natural Resource Economics Div.

2.0136,

ENERGY AND PROTEIN PRODUCTION FROM PULP MILL WASTES

M.F. Jurgensen, Michigan Technological University, School of Forestry & Wood Products, Dept. of Forestry, *Houghton, Michigan* 49931 (E(11-1)-2983)

Lignosulfonate is the major waste product from the sulfite pulping industry. The resulting waste solution, spent sulfite liquor (SSL), contains approximately one ton of organic solids per ton of pulp produced. Total annual production of organic solids exceeds 2.0 million tons, which is equivalent to approximately 40 trillion Btu's or 40 billion cubic feet of natural gas. This represents a large potential source of useful energy if converted to liquid or gaseous fuels, or protein if metabolized by the proper microorganisms. Currently, the bulk of this waste material is discharged into water systems after some form of biological waste treatment or evaporated with some of the cooking chemicals and energy recovered by burning the residue. However, much of the potential energy available from this organic waste is lost by these treatments. The current shortage of fuel resources makes the more efficient utilization of this energy source both urgent and appealing. This proposed research seeks to investigate the possibility of biologically converting most, if not all, of the organic resources available as SSL into protein plus a usable energy source, methane. A conceptual process has been developed which utilizes ozonation to desulfonate the lignin followed by three stages of biological digestion. These stages are designed to first convert the organic fraction of SSL into yeast protein followed by methogenesis utilizing anaerobic organisms and finally aerobic digestion. This study will concentrate on the effects of ozonation on yeast fermentation as well as the increased conversion of the remaining organic fraction to methane.

SUPPORTED BY U.S. Dept. of Energy

2.0137,

ENGINEERING SYSTEMS AND MECHANIZATIONS FOR NORTHERN FOREST STANDS

R.A. Arola, Michigan Technological University, U.S. Dept. of Agriculture North Central Forest Expt. Station, *Houghton, Michigan* 49931 (NC-3701)

OBJECTIVE: Develop engineered systems and equipment which are needed to economically meet forestry objectives in northern forest stands.

APPROACH: Research will concentrate on harvesting and transportation of the residues left in the forest. Residue recovery will be approached as a material handling and processing problem in both mature and immature forests. New equipment and systems will be developed to economically convert low-valued, residue-type materials such as small trees, tops, limbs, stumps, and roots into a form suitable for handling, transporting, and product development. Research will also include the problems of production of energy from forest resources, with particular emphasis on forest residues and mortality stands. Approaches will include recovery of residues for energy uses, methods and equipment to convert rough residues into suitable fuel products as well as achieving quality control of residues by developing concepts for ridding such fuels of moisture and contaminants (dirt and grit).

PROGRESS: The recovery of tops and limbs from sawlog operations in preliminary field trials with a prototype topwood harvester indicated costs of about $2 per ton to prepare tops for skidding, an average recovery of one green ton per hardwood sawlog top, and a productivity of one-half acre per hour. --Growth and damage evaluations over three growing seasons on the previously mechanized thinned hardwood stand indicate that the stand is responding favorably. Commercial application of the mechanized thinning research has taken place. --A patent has been granted on the helical head communiting shear. --The previously developed compression debarking system is being tested commercially on pilot scale. A combined vacuum-airlift and compression debarking system has also been developed. Preliminary estimates indicate that the capital investment of a large chip debarking plant can be reduced by one-half and the unit production costs reduced by 40% with the combined system. A forest products company has scaled-up this combined system to a pilot process to continue further research work. --A site specific study of the feasibility of making pulp and paper industries energy self sufficient through the use of forest residues as an energy source is being conducted.

SUPPORTED BY U.S. Dept. of Agriculture, Forest Service, North Central Forest Experiment Station

2.0138,

ENGINE MODIFICATIONS FOR USE OF METHANOL FUEL IN HIGHWAY VEHICLES

D.J. Patterson, University of Michigan, Ann Arbor Campus, School of Engineering, Dept. of Mech Engin, *Ann Arbor, Michigan* 48104

Methanol can be used straight as a fuel to replace gasoline or it can be used as a blend with gasoline to extend the supply. Problems of starting, vapor lock, corrosion and phase separation of methanol/gasoline blends in the presence of water have been uncovered. Possible solutions are modifying the fuel, modifying the engine, or a combination. This project is aimed at reviewing various practical solutions and assessing them. The tasks below are being conducted both for pure methanol and methanol/gasoline blends and are restricted to engine modifications. Task 1--Candidate Solutions and Criteria for Selection. This task includes a review of published literature and in-depth discussions with industry and laboratory researchers in order to delineate the problems and identify desirable engine and fuel system modifications for good performance, driveability and emission characteristics. Screening criteria and a methodology for analysis are being developed. Task 2--Analysis of Candidate Solutions. In this task the problems of retrofitting carbureted engines and application to future engines for the 1985/2000 time frame are being considered. For each alternative the promising candidate solutions and advantages are being identified and problems delineated. Based upon the information obtained under Task 1, the potential solutions are being rated in relation to one another. Future research needs are being identified.

SUPPORTED BY U.S. Dept. of Energy

2.0139,

NUTRIENT UTILIZATION IN INTENSIVELY CULTURED FOREST CROPS

J.R. Boyle, University of Michigan, Ann Arbor Campus, School of Natural Resources, *Ann Arbor, Michigan* 48104 (MICY00070-F)

OBJECTIVE: Evaluate nutrient requirements of intensively cultured forest crops. Evaluate capacities of soils to supply these nutrients.

APPROACH: Review the literature and file data on nutrient uptake of intensively cultured forest crops and related information on soil supplies of nutrients and ecosystem nutrient dynamics. Analyze data on soil properties and plant nutrient contents for whole-tree chipping operations. Calculate preliminary nutrient budgets and define additional needed research.

PROGRESS: A system for evaluating potential impacts of whole-tree harvesting on site quality is proposed for use by forest land managers. The system includes calculation of site nutrient budgets by using best available information on inputs, transformations, and outputs of essential elements. This approach can aid in decisions as to where whole tree harvesting might damage future site quality.

SUPPORTED BY Michigan State Government

2.0140,

FLAME PROPAGATION, AUTOIGNITION AND COMBUSTION IN ALCOHOL-PETROLEUM-AIR MIXTURES

N.A. Henein, Wayne State University, School of Engineering, Dept. of Mech Engin, *5950 Cass Ave., Detroit, Michigan* 48202 (EC-77-S-02-4486)

The scope of work under this contract is an experimental investigation to perform characterization of combustion phenomena specific to alternate fuels in internal combustion engines for optimum utilization of these same fuels, and to determine those combustion characteristics of candidate substitute fuels in cyclic combustion which will effect time by switching from premium petroleum derived fuels.

SUPPORTED BY U.S. Dept. of Energy, Office of Fossil Energy

2.0141,

COMBUSTION AND EMISSION CHARACTERISTICS OF ALCOHOLS AND OTHER ALTERNATE FUELS IN GASOLINE AND DIESEL ENGINES

N.A. Henein, Wayne State University, School of Engineering, Dept. of Mechanical Engineering, *5950 Cass Ave., Detroit, Michigan* 48202 (EC-77-S-02-4486)

The combustion and emission characteristics of alternate fuels are obtained in experimental research gasoline and diesel engines. The data obtained are analyzed and correlated in terms of the fuel properties, the fuel-air mixture properties, engine speed and other design parameters. The experimental part is conducted on the CFR Gasoline, CFR Diesel, and a Single Cylinder Research Diesel engine. The inlet conditions to the research diesel engine are controlled to simulate the low compression ratio, as well as the turbocharged diesel engines. The alternate fuels are simulated by using blends of primary reference fuels and blends of gasoline and diesel fuels. Other alternate fuels being tested include blends of methanol and gasoline (Indolene). The data obtained upon completing the program will be needed by the design engineers to design the gasoline and diesel engines to run on the future alternate fuels or for adapting the current production engines to the alternative fuels.

SUPPORTED BY U.S. Dept. of Energy

2.0142,

HOMESTEAD BIOMASS CONVERSION

A. Rutan, Rutan Research, *Stillwater, Minnesota*

The project would demonstrate the utilization of methane gas in a practical way to the needs of an ordinary house. It would include construction of a greenhouse and animal shelter combination which would include solar collectors and a movable insulation system to decrease heat loss during periods of no sun and at night. Waste products would be used to provide methane gas to be utilized in the home and as heat for the digestion. The entire system would be open for public visits.

SUPPORTED BY Minnesota State Government

2.0143,

ECONOMIC ANALYSIS OF THE CHANGING DEMAND FOR TIMBER IN THE LAKE STATES

E. Kallio, University of Minnesota, Duluth Campus, U.S. Dept. of Agriculture North Central Forest Expt. Station, *331 Science, Duluth, Minnesota* 55812 (NC-4203)

OBJECTIVE: Determine and measure effects on the future demand for timber in the Lake States. Determine the economic limitations of using forest residues as an energy source for the pulp and paper industry. Determine the economic consequences of full tree removal in the aspen-birch type. Determine barriers affecting the more efficient use of softwood lumber for structural use in residential housing.

APPROACH: Wherever possible, information will be collected on wood product demand from secondary sources. Information on full tree removal and availability of forest residues for fuel will be collected from existing forest survey plot data. residue measurement, and harvest and transport cost estimation. Simulation and access models will be used to analyze the data. Information collected from lumber truss fabricators and other sources will be used in determining barriers affecting the more efficient use of softwood lumber.

SUPPORTED BY U.S. Dept. of Agriculture, Forest Service, North Central Forest Experiment Station

2.0144,

BIOCHEMICAL AND ENGINEERING CONVERSION SYSTEMS - DESIGN AND PROTOTYPE DEVELOPMENT

D.B. Kittelson, University of Minnesota, Minneapolis Campus, Graduate School, *322 Johnston Hall, Minneapolis, Minnesota* 55455

This project consists of three phases: a. The design and construction of the hot tumbler reactor and the testing of this reactor using different feedstocks and at different operating conditions. If the system yields are high, it could serve as the heart of a relatively simply inexpensive pyrolysis system. High temperature rotating seals and bearings will be designed. b. The use of a fluidized bed pyrolysis reactor for the conversion of biomass. This is a second generation reactor which will be able to allow continuous feeding of biomass and allow fluidization with pyrolysis products rather than nitrogen. This project would investigate the influence of the bed on operating conditions and yields. c. The use of enzymology and micro-organisms fermentation for converting ground plant materials, pyrolyzed material, and plant starches to nutrient sugars and other chemicals. It will involve use of moderately high temperatures 40-90 degrees C., which would allow utilization of waste heat in some cases.

SUPPORTED BY Minnesota State Government

2.0145,

ENERGY PLANTATIONS FOR MINNESOTA

D. Rose, University of Minnesota, Minneapolis Campus, Graduate School, *322 Johnston Hall, Minneapolis, Minnesota* 55455

Estimates of wood resource supply by quantity, distribution and potential productivity for a selected county. An economic analysis of different production alternatives for wood. The development of operational plans for possible implementation in pilot scale testing. The assessment of social and environmental impacts of proposed fuel production systems.

SUPPORTED BY Minnesota State Government

2.0146,

UTILIZATION OF ENERGY FROM METHANE GENERATION

P. Goodrich, University of Minnesota, Minneapolis Campus, Inst. of Technology, Dept. of Agricultural Engineering, *105 Morrill Hall, Minneapolis, Minnesota* 55455

This project proposes to demonstrate the feasibility of integrating a methane (bio-mass) powered electrical generator into an electrical distributor system on a gallon anaerobic digester operating on a privately owned hog farm which has been producing biogas since June, 1965. This gas will be used to produce electricity with existing biogas fueled motor-generator sets. The study will look at the uses of the electricity of the farm and the possibility of exporting excess energy along the power company line to other users in the system.

SUPPORTED BY Minnesota State Government

2.0147,

PLANT ENERGY PLANTATIONS

D.N. Moss, University of Minnesota, Minneapolis Campus, School of Agriculture, Dept. of Agronomy & Plant Genetics, *105 Morrill Hall, Minneapolis, Minnesota* 55455

Determine productivity of cattails in solid stands. Determine the optimum fertilization of cattails to maximize production. Determine if peat is a suitable rooting medium. Determine depth and distribution of rhizones in peat as preliminary information to design harvest methods. Determine the optimum density for biomass production. Determine the composition of cattail biomass, particularly the relative amounts of cellulose and starch.

SUPPORTED BY Minnesota State Government

2.0148,

PYROLYSIS OF CROP AND FORESTRY RESIDUES

D.B. Kittelson, University of Minnesota, Minneapolis Campus, School of Engineering, Dept. of Mech Engin, *105 Morrill Hall, Minneapolis, Minnesota* 55455

Description: The project will investigate means of converting crop and forest residues into useful fuel materials by pyrolsis. The main emphasis of the research is on low temperature (250-300 degrees C) pyrolysis. Under these conditions the yield of tar should be maximized and the yields of solid char and gas phase pyrolysis products minimized. The effect of operations conditions on tar yield and the fuel value of the tar will be explored. The results will serve as data for design of such pyrolysis units.

SUPPORTED BY University of Minnesota

2.0149,

ECONOMICS OF ANIMAL WASTE MANAGEMENT AND ENVIRONMENTAL QUALITY

B.M. Buxton, University of Minnesota, St. Paul Campus, Agricultural Experiment Station, Dept. of Agricultural Econ, *St. Paul, Minnesota* 55101 (NRE-41-302-27-01)

OBJECTIVE: Evaluate the economic impact on livestock farmers, consumers, processors, marketing firms, and taxpayers of proposed and potential guidelines; evaluate alternative animal waste systems; and determine least-cost abatement practices.

APPROACH: The cattle feeding, dairy, hog, and poultry portions of the livestock industry will be studied. First, attention will focus on the economic impact of proposed point source effluent limitation guidelines. Secondly, the economic impact of alternative measures and guidelines relating to the control of nonpoint sources of animal waste will be analyzed. The basic analytical approach will be a series

of partial equilibrium analyses employing budgeting and linear programming techniques.
PROGRESS: Over one-fifth of all farms producing hogs in the 15 major hog-producing states were estimated to have runoff problems. The impact of runoff control would fall more heavily on small producers. Farms selling fewer than 100 hogs annually would incur investments of about $61 per hog and additional annual costs of $4.24 per 100 pounds of hogs sold. Farms with output above 1,000 hogs would require $4.00 investment per hogs and $0.26 of additional operating costs per 100 pounds. However, after adjustments to comply with environmental regulations are completed, pork will be little or no more expensive to the consumer. Feedlots of over 2,000 head capacity accounted for 58 percent of all feed cattle marketings in the U.S. in 1973. Fifty-six percent of the feedlots spread manure on land that they operate. The average application rate was 18 tons per acre. The value of gas (fuel) and sludge (fertilizer) from anaerobic production of methane from animal waste is expected to exceed annual costs if the output can be fully used. Michigan feedlots would adjust to pollution abatement controls by modest reductions in beef output.
SUPPORTED BY U.S. Dept. of Agriculture, Economics Statistics & Cooperatives Service, Natural Resource Economics Div.

2.0150,
FARM ANIMAL WASTE DISPOSAL
P.R. Goodrich, University of Minnesota, St. Paul Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *St. Paul, Minnesota* 55101 (MIN-12-060)
OBJECTIVE: Evaluate gases from manure for chemical components and effects on man and animals; methods of reclaiming, storing, processing and refeeding animal wastes back to animals for effect on animal health, production. Develop components for collection, storing, treating of animal manure and evaluate their economy, effect on production and their effect on environment. Evaluate effect of rates, frequency of applying animal manure to soils.
APPROACH: Manure gases have been analyzed by gas chromotograph and evaluated using human odor panels. Limited results are available relating gas composition, production to various waste management systems; effects on animal, human health and production. Reclaiming, recycling the usable constituents has been studied to determine palatability and feed conversion on a limited number of animals. Detailed investigations of toxicity, microbiological effects and residual storage of pharmaceuticals in the animal are lacking. Evaluations of separating, storing and handling systems are extremely limited and not for waste management in cold climate.
PROGRESS: Animal waste lagoons in Minnesota sampled several times a year taking depth of sludge measurements. Samples showed sludge depths from 6' up to 8 feet. Four mini lagoons constructed with liners of special sealants and filled. Significant nitrate movement to a depth of 8 feet observed in soil beneath heavy applications of manure. No significant yield differences were shown between manure and fertilizer treatments. A 10,000 gallon on-farm digester has been constructed and operated in Minnesota climate. Twenty gallon laboratory digesters fed at 0.2 lb. TVS/ft stirred 2 times per week produce most gas. Stirring more than 2X/week did not increase gas production or quality. Sloped solid floors evaluated for buildup of manure under cattle feeding and traffic. Cattle cleanest on floors sloped 1 inch/ft. while the most manure was on the floor and cattle when the slope was 1/4'/ft.
SUPPORTED BY Minnesota State Government

2.0151,
BIO-GAS PRODUCTION FROM ALLIGATOR WEEDS
A. Latif, Alcorn State University, Undergraduate School, Dept. of Biology, *Lorman, Mississippi* 39096
Bio-gas and methane production from the microbial anaerobic decomposition of alligator weeds (Alternanthera philoxerides) (Mart.) Griesb., was investigated. These experiments demonstrated the ability of alligator weeds to produce an average of 7.5 ml of methane gas per gram of wet plant weight. The study revealed that sample preparation, light intensity, addition of reducing agents and other additives had no significant effect on bio-gas and/or methane production. Increasing initial pH of the liquid content of the fermentation unit increased bio-gas and methane production significantly. Raising incubation temperature from 24 degrees C to 35 degrees C, increased bio-gas and methane production but reduced the time lag between the production of biogas and production of methane gas. After the gas production ceased, the accumulated sludge in each fermentation unit was throughly shaken and the liquid content was used for bacterial enumeration, isolation and characterization. This work is still in progress. The result of this study will be reported in the annual report.
SUPPORTED BY U.S. National Aeronautics & Space Admin., Office of Org. & Management, Office of University Affairs

2.0152,
RESEARCH EQUIPMENT DESIGN AND DEVELOPMENT
F.L. Shuman, Mississippi State University, Agricultural & Forestry Experiment Station, Dept. of Agricultural & Biological Eng, *102 Experiment Station Bldg., Mississippi State, Mississippi* 39762 (MIS-7006)
OBJECTIVE: Provide engineering assistance in the design, modification and development of experimental research equipment. Determine the feasibility of 'in-house' fabrication of such equipment as opposed to contracting for fabrication or purchase of commercially available equipment. Provide assistance in developing specifications for research equipment to be purchased, leased or obtained by contract.
APPROACH: Establish and staff an engineering facility to provide continuing assistance to Mississippi Agricultural and Forestry Experiment Station scientists in the design, supervision of construction, modification, and development of experimental research equipment.
PROGRESS: Work was done in support of various research projects within the MAFES system. Much of this work was in the nature of short term consultation and minor design rather than extensive formal design and development. The major effort during this reporting period has been concerned with the design of an environmental chamber - Biology Laboratory - Greenhouse complex for use in the research program at Alcorn State University. Other work has involved the design of methane gas generation and collection devices associated with research in animal waste management (MIS-0203). Assistance has been provided in the design of equipment used in the beef cattle research work at the Poplarville Station. Considerable effort has been expended in the area of improving the safety of research equipment, including roll-over protective structures for mobile machines.
SUPPORTED BY Mississippi State Government

2.0153,
SYSTEMS STUDY OF FUELS FROM GRAINS AND GRASSES
W. Benson, Midwest Research Inst., *425 Volker Blvd., Kansas City, Missouri* 64110
No summary has been provided to the Smithsonian Science Information Exchange.
SUPPORTED BY U.S. Dept. of Energy

2.0154,
REFUSE DERIVED FUEL SOURCES AND UTILIZATION
A.D. McElroy, Midwest Research Inst., *425 Volker Blvd., Kansas City, Missouri* 64110 (B624B-T61)
The objective of this study is to identify sources of feedstocks (wastes) compatible with existing waste-as-fuel processes and 'product' fuel users. This effort calls for a national identification of waste sources (municipal, industrial, agricultural/quantities and locations by counties) and current fuel users (residential, utility boilers, etc. and locations by counties). It is envisioned that the results of this effort will be displayed in a tabular form according to geographic areas as well as displayed on one or a series of maps.
SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Industrial Environmental Research Lab.

2.0155,
SYSTEMS STUDY OF FUELS FROM GRAINS AND GRASSES
M.C. Noland, Midwest Research Inst., *425 Volker Blvd., Kansas City, Missouri* 64110
Bioconversion concepts for grains and grasses will be examined for technical and economic feasibility. Included are production of plant biomass, conversion into energy by direct means or by production of storable fuels, distribution costs, economic factors, and environmental impacts. Attractive crops that could be used in systems leading directly to proof-of-concept experiments will be delineated.
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0156,
ENVIRONMENTAL ASSESSMENT OF WASTE-TO-ENERGY (388)
M.P. Schrag, Midwest Research Inst., *425 Volker Blvd., Kansas City, Missouri* 64110 (B624B-388)
The objective of this project is to characterize the liquid, gaseous, and solid emission from various waste to energy systems. The characterization will be based on actual data obtained from on-site sampling operations. The first report from this project was distributed in July '77; it represented a collection of previously obtained data and was called a 'Source Assessment Document for Waste-As-Fuel Processes.'
A co-firing of wood waste with coal process has been characterized for environmental emissions, as has a waste pre-processing (shredder/air classification) plant in Houston, Texas. Characterization of several waste pyrolysis plants is envisioned, in addition to that of waterwall incineration plants.
SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Industrial Environmental Research Lab.

2.0157,
ANATOMY AND PROPERTIES OF MISSOURI WOODS
E.A. McGinnes, University of Missouri, Columbia Campus, Agricultural Experiment Station, Mcintire Stennis Program, *130 Jesse Hall, Columbia, Missouri* 65201 (MO-00165)
OBJECTIVE: Evaluate fundamental, chemical and physical properties of normal and abnormal wood of tree species in relation to anatomical structure of wood as well as conditions of tree growth. Applied research to improve processing procedures for manufacture of wood products.
APPROACH: Basic research on fundamental properties conducted on normal or abnormal xylem tissue obtained from existing silvicultural study plots where available; specific studies designed for statistical analyses where applicable. Many fundamental properties to be studied will be measured by existing standard methods or modifications thereof. Applied studies to be planned jointly with extension and industry personnel. Studies to be of short-term nature, problem oriented, but related to basic studies so that both students and technicians can be involved. Procedures standard if possible.
PROGRESS: (Fundamental Properties) - publications were released on evaluation of wood color changes due to various types of artificial lighting; on wood injury and resultant wood formation and how such wood is a problem in both seasoning and finishing. Publications were released on shake formations in hardwoods and on methylation studies of scarlet oak. These studies are of importance in better understanding of events following wounding to trees. (Applied Studies) - publications on charcoal shrinkage released; Dry Kiln installed and in use. First drying studies will be on black walnut. Additional studies on charcoal formation both in commercial and laboratory kilns is underway.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Missouri

2.0158,
LIVESTOCK RESIDUE UTILIZATION SYSTEMS
D.M. Sievers, University of Missouri, Columbia Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *130 Jesse Hall, Columbia, Missouri* 65201 (MO-00080)
OBJECTIVE: Develop livestock residue management systems which are adaptable to Missouri's conditions and maximize resource utilization.
APPROACH: Livestock residue utilization systems holding most promise for adoption under Missouri conditions will be incorporated into existing and future animal production facilities on university farms to study their value for pollution abatement and resource utilization. Systems will be installed and studied as components; e.g., collection, treatment, processing and utilization components. Components to

be studied include hydraulic flushing, solids-liquid separation, settling basins, anaerobic lagoons, soil-plant filters, anaerobic digesters, oxidation ditches and irrigation equipment. Cooperative research with private producers will be used where appropriate opportunities exist to evaluate unique components or systems and where field installations can serve as demonstrations to the farming community.

PROGRESS: The farm-size digester on the UMC swine farm was placed into operation October 1. Currently, the digester is producing 1600-1800 ft of bio-gas/day. The gas is consistently running 58% CH(4). The pH is stable at 6.6-6.8 and the alkalinity is 1800 mg/l CaCO(3). The mechanical and electrical equipment is functioning well. Most problems encountered have occurred in the settling-collection pit where agitation of manure solids has been a problem. A study on the relationships between salt concentration and bacterial activity in an anaerobic dairy lagoon has shown that activity (measured as gas production) begins to decrease at an electrical conductivity (E.C.) near 9,000 micromhos/cm. Decreases in bacterial activity decrease with increasing salt according to the equation Y = 1894X where Y activity and X is E.C. Bacterial activity was inhibited by various salts according to the folling decreasing scheme K greater than Na greater than Ca greater than Mg greater than NH(4). A new bacterial culture medium has been developed that consistently recovers up to 60% of the organisms obsreved microscopically within the UMC digester.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Missouri

2.0159,

CONSTRUCT, OPERATE, AND STUDY A FARM-SIZE METHANE GAS GENERATION PLANT

D.M. Sievers, University of Missouri, Columbia Campus, School of Engineering, Dept. of Agricultural Engineering, *103 Engineering, Columbia, Missouri* 65201

No summary has been provided to the Smithsonian Science Information Exchange.

SUPPORTED BY Missouri State Government

2.0160,

FACTORS AFFECTING LAGOON PERFORMANCE

J.R. Fischer, University of Missouri, Columbia Campus, U.S. Dept. of Agriculture Agricultural Research Service, Bioengineering Res, *Agricultural Eng. Bldg. T 12, Columbia, Missouri* 65201 (3402-14740-002)

OBJECTIVE: Derive a functional relationship to predict lagoon performance for livestock waste disposal.

APPROACH: Studies will be made to improve the prediction of the lagoon's ability to convert solids into liquids, perform some degradation of wastes, and do the above with a minimum of odor. Detailed engineering and biochemical studies and analyses will be made to relate variables such as percentage volatile solids destroyed as a function of pH, temperature, loading rate, and volatile acids. After the relationships of the variables to the performances of the lagoon have been developed for each variable, then a mathematical relationship will be developed to study the possible interactions of the variables on lagoon performance. Research will be conducted in the field in order to obtain sufficient information to relate such variables as temperature to lagoon performance, also, climatological data will be considered in the mathematical relationship.

PROGRESS: A 6 ft anaerobic digester, operated for the past year, was used to evaluate the effects of loading rate on digester performance. Satisfactory digester stability and gas production of 2 ft per ft of digester was obtained with loading rates of 0.15 up to 0.18 lb VS/ft. The ammonia concentration was in the range of 1200 mg/liter. One-third of the gas produced is needed to heat the digester. An experiment was designed to determine the settling of VS, TS, COD, Total Kjeldahl nitrogen, ammonia and phosphorus in swine waste. Since potassium was in the colloidal state and did not settle, it was not evaluated. Utilizing this settling data, a design procedure for a settling basin used in conjunction with an anaerobic digester was developed. A 20,000-gallon anaerobic digester has been designed and is being installed on the UMC Swine Farm. The digester will handle the waste from a 320-hog finishing barn. It is expected to be completed this fall. The digester will feature gas agitation, and the methane produced will be used to heat the digester. An anaerobic dairy lagoon has been monitored this past year. Samples have been taken at various depths and at two locations in the lagoon. Also, temperatures are continually recorded at various depths in the lagoon. Temperatures in the lagoon have reached 75 degrees F in the summer and then reduced to 35 degrees F this winter. No build-up of solids has occurred in the lagoon this winter.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Mid Great Plains Area

2.0161,

EQUIPMENT AND STRUCTURES TO MANAGE AND UTILIZE AGRICULTURAL WASTES AND RESIDUES FOR ENERGY PRODUCTION

J.R. Fischer, University of Missouri, Columbia Campus, U.S. Dept. of Agriculture Agricultural Research Service, Bioengineering Res, *Agricultural Eng. Bldg. T 12, Columbia, Missouri* 65201 (3402-20400-003)

OBJECTIVE: Develop methods and equipment for on-farm anaerobic digestion of agricultural residues for energy utilization.

APPROACH: Laboratory studies on anaerobic digestion will develop design and operational criteria for digestion equipment through determination of physical and chemical parameters such as optimum carbon-nitrogen ratio, digester loading rates, gas production, heavy metal, ammonia, and antibody toxicities. The effect of using a hydraulic manure flushing system and settling basin in conjunction with digestion will be investigated. A prototype anaerobic digester, funded by the University of Missouri, is being built at the UMC swine complex. The design and operational feasibility of this digester will be evaluated to provide a basis of recommendations for on-farm facilities. These studies are being coordinated with research at the NRRC on methane generation from animal waste.

PROGRESS: The 5000-ft farm anaerobic digester was started on 9/30/76 by adding swine waste and municipal digested effluent to the digester for several days. Thereafter, only swine manure was added daily. Within 15 days, detectable amounts of gas were measured. The digester processes the waste from a 40-sow farrow-to-finish confinement system. The digester is operated at 15-day detention time, 95 F, and at a loading rate of approximately 0.1 lb volatile solids/ft /day. Gas production is approximately 1600 ft /day with a potential gas production of over 9000 ft 3/day. For December, approximately 25% of the potential gas production was used to maintain the digester at 95 F. Thirty percent of the gas used to maintain the digester was used to heat the incoming manure slurry to 95 F. The 15-ft model digester operated this past year at a loading rate of 0.25 lb volatile solids/ft /day at a detention time of 15 days and a temperature of 95 F. Gas production was 2.2 ft gas/ft of digester liquid. The gas composition was 59% methane and 39% carbon dioxide. Total and volatile solids destroyed were 52% and 61%, respectively. Ammonia nitrogen concentrations in the digester were 3000 mg/liter. A medium developed for a swine digester recovered 60% of the bacteria. Approximately 1% of the bacteria in the digester was methanogenic bacteria. No nitrogen, phosphorus, or potassium were lost during digestion.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Mid Great Plains Area

2.0162,

ENERGY VULNERABILITY OF ALTERNATIVE SYSTEMS OF AGRICULTURAL PRODUCTION

B. Commoner, Washington University, School of Arts & Sciences, Dept. of Biology, *4559 Scott Ave., St. Louis, Missouri* 63130

This research is a continuation of analysis of alternative agricultural production techniques that have the potential for increasing the efficiency with which limited resources are used - NSF Grant AER 74-18438. The first component continues a comparative study of Corn Belt farms that do and do not use chemical fertilizers and pesticides, with particular emphasis on field measurements of corn and wheat yields under the two systems, as well as measurements of their comparative effects on soil properties and on grain protein.

The second component extends and generalized work previously undertaken on the impact of energy problems and declining water tables on the economics of crop production under sprinkler irrigation in the Great Plains. This work will encompass more locations in the Plains and will compare various methods for allocating limited energy and ground water reserves.

The third component is an investigation of the use of sewage sludge as a fertilizer for Corn Belt farms. This work will analyze the economic viability and resource-intensiveness of sludge use, and will seek to identify the factors working for and against farmers' willingness to use sludge and other off-farm organic wastes. It will also examine the comparative effects of sludge and conventional fertilization on the nutrient level of several Midwestern soils under typical sludge utilization practices.

SUPPORTED BY U.S. National Science Foundation, Div. of Advanced Energy & Resources Research & Technology

2.0163,

ANIMAL WASTE STABILIZATION

J.C. Boyd, Montana State University, Agricultural Experiment Station, Dept. of Animal & Range Science, *Bozeman, Montana* 59715 (MONB00181)

OBJECTIVE: Determine factors affecting the minimum aerobic treatment which will stabilize odors and retain maximum nutrient content in animal wastes. Study factors affecting the establishment of a dominant micro flora and the effectiveness of such a microflora in odor control and nutrient recovery. Study alternate uses for odor stablized animal waste other than return to agricultural land.

APPROACH: Laboratory and pilot plant studies on oxygen level, pH, and nutrient recovery in an odor stabilization process and odor stabilized products.

PROGRESS: As indicated in previous reports, ammonia nitrogen in aminal waste (a) makes up some 30 to 40 percent of the total nitrogen, (b) is not utilized by non-rumin animals, (c) is not efficiently converted to bacterial cells, (d) at certain concentrations may be inhibitary to bacterial growth, and (e) is lost in drying of the waste material. The principle objective of this year's work has been investigation of ways to more fully utilize this nitrogen fraction. Much of the work has been done in cooperation with Dr. Robbins of the Chemistry Department. Three research applications from grants of financial aid were proposed and one entitled 'Biological & Bio-chemical Techniques Applied to the Conversion of Waste Material to Useful Products' was funded in the Chemistry Department. Chemical investigation on methodology for analysis of animal waste materials for ammonia levels, and for fermentable carbohydrate levels have been reported under Project 250. Stripping of ammonia nitrogen from the animal waste material has been successful with about 90 percent recovery. Adding of additional fermentable carbohydrate to encourage greater bacterial utilization of the ammonia nitrogen resulted in some increase in methane production when glucose was used. Use of chemically treated straw to provide the additional fermentable carbohydrates was attempted but could not be adequately evaluated due to mechanical problems in handling the straw.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Montana

2.0164,

AMMONIA PRODUCTION FROM ANIMAL WASTE

J.E. Robbins, Montana State University, Agricultural Experiment Station, Dept. of Chemistry, *Bozeman, Montana* 59715 (MONB00250)

OBJECTIVE: Establish a simple fast, and sensitive method for quantitative assay of ammonia in fecal material extracts. Devise an efficient method of releasing and collecting ammonia from fecal matter. Explore enzymatic methods for increasing the ammonia yield from F.M. Determination of the optimum N/C ratio in F.M. for maximum methane yield from anaerobic fermentation. Establish a pilot plant scale production of ammonia.

APPROACH: The approach for objective 1 is drawn from enzymatic catalyzed reactions in ammonia metabolism. A dehydrogenase spectrophotometric method will be used. Objective 2 will be based on acid-base equilibria. This should allow solvation or dissolution of ammonia gas. Objective 3 will entail studies using the enzymes urease, uricase and others to release additional ammonia. Objective 4 would involve removing various amounts of nitrogen (N) from F.M. and subsequent fermentation of the F.M. monitoring the methane yield. Objective 5 is dependent upon 1-4.

PROGRESS: We have set up an anaerobic fermenter in our laboratory in order to monitor the efficiency of animal waste digestion. In addition to analyses of ammonia production we are analyzing for cellulose, glucose, reducing sugars, methane and carbon dioxide. We have established analyses for all of these.

Our plans are to begin changing available carbohydrate and observing the effects via the above analyses. In order to increase the available carbohydrate in waste we are looking at the possibility of utilizing fungi to cause hydrolytic breakdown of cellulose. We have selected two fungal species for this purpose and have established culturing techniques.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Montana

2.0165,

ECOLOGY OF METHANE-PRODUCING BACTERIA

D.M. Ward, Montana State University, School of Letters & Sciences, Dept. of Microbiology, *Bozeman, Montana* 59715

The ecology of methane production will be studied in a hot springs environment in which anaerobic decomposition occurs at high temperatures. The objectives include 1) development of methods for detection of methane-producing bacteria by fluorescence microscopy and autoradiography, 2) analysis of the ecology of methane bacteria and the biochemistry of methane production in nature and 3) the isolation and characterization of methane bacteria native to thermal springs. These studies will contribute to an understanding of the role of these organisms as agents of geochemistry, both past and present, and of their potential for utilization in high temperature systems of organic waste fermentation and methane fuel production.

SUPPORTED BY U.S. National Science Foundation, Div. of Environmental Biology

2.0166,

NEW AND IMPROVED PROCESSES FOR WESTERN SOFTWOODS

E.S. Kotok, U.S. Dept. of Agriculture, Forest Service, Intermountain Forest & Range Experiment Station, Forestry Sciences Lab., *Missoula, Montana* 59801 (INT3201)

OBJECTIVE: Obtain the information necessary for the development of a numerically controlled dryer and determine the suitability of various wood species for millwork and associated products.

APPROACH: Numerically controlled wood-drying equipment requires knowledge of the relationship between wood characteristics and drying, measurement of these characteristics for machine inputs, and monitoring of the characteristics to control the drying process. This information will be obtained by laboratory experiments measuring energy transfer systems, intermediate moisture content levels, wood/moisture/energy requirements and remote sensing techniques. The suitability of species for millwork products will be accomplished through the development of millwork criteria and evaluation of different species by means of machining tests. Species availability, smoothness of wood, and ease of cutting are probably the main criteria that will be used to rate the various species for interchangeability.

PROGRESS: Multiple regression analysis of several variables enables prediction of moisture content in Douglas-fir and ponderosa pine lumber and internal vapor pressures generated in drying have been determined which enable more efficient drying schedules. A multi-discipline study of field chipping of residues under direction of this RWU has completed initial phases and pre- and post-inventory and product recovery data have been published. Continuing work is evaluating the influence of residue removal upon area esthetics, hydrology, soil chemistry and nutrient cycling, regeneration, and fuel characteristics, as well as influence upon the economics of subsequent management activities.

SUPPORTED BY U.S. Dept. of Agriculture, Forest Service, Intermountain Forest & Range Experiment Station

2.0167,

PYROLYTIC CONVERSION OF LIGNOCELLULOSIC MATERIALS

F. Shafizadeh, University of Montana, School of Arts & Sciences, Dept. of Chemistry, *770 Eddy St., Missoula, Montana* 59801

The impending shortage of chemicals and other materials and the limited supply of petroleum necessitate new efforts for efficient utilization of renewable lignocellulosic materials. Pyrolysis, the controlled thermal treatment of materials, provides an efficient process for converting lignocellulose into a wide range of useful products including sugars, chemicals, solvents, charcoal and fuel. The overall objective of this project is to examine promising routes for converting lignocellulosic materials to useful chemicals through pyrolytic means. Specific objectives are to: 1. investigate the thermal deploymerization of cellulose in wood and agricultural materials into levoglucosan (an anhydride of glucose); 2. examine in an integrated fashion, the pyrolytic processes for producing furfural, acetic acid, methanol and carbon as byproducts from the hemicellulose and xylan components of the raw materials; 3. establish the application and utility of the novel pyrolytic products, especially levoglucosan and levoglucosenone; 4. investigate the use of thermal treatments to increase the susceptibility of cellulose to enzyme hydrolysis.

SUPPORTED BY U.S. National Science Foundation, Div. of Problem Focused Research Applications

2.0168,

ANAEROBIC FERMENTATION OF LIVESTOCK AND CROP RESIDUES

A.G. Hashimoto, U.S. Dept. of Agriculture, Agricultural Research Service, U.S. Meat Animal Research Center, *Clay Center, Nebraska* 68933 (3415-20400-005)

OBJECTIVE: Determine feasibility of anaerobic fermentation to recover methane, protein and plant nutrients from agricultural residues.

APPROACH: The work plan is divided into four tasks: Parametric testing; biomass recovery; biomass nutritive evaluation; and scale-up and economic evaluation. Parametric testing evaluates the effects of operating parameters (mixing, temperature, residence time and loading rate) on biomass and methane production. Biomass Recovery will be by centrifugation and lower cost solids recovery systems. Biomass nutritive evaluation consists of the chemical composition of the biomass and in vitro and in vivo digestibility. Capital and operating costs of the overall system will be evaluated.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Mid Great Plains Area

2.0169,

DEVELOPMENT OF TECHNIQUES TO MEASURE AND PREDICT BIOMASS OF SINGLELEAF PINYON AND UTAH JUNIPER

E.L. Miller, University of Nevada, Reno Campus, Agricultural Experiment Station, *Reno, Nevada* 89507 (NEV00664)

OBJECTIVE: Develop prediction equations which use measureable, independent tree variables to estimate above-ground biomass as related to resource potentials and quantity of fuel. Obtain data for analysis of growth relations and site quality of pinyon-juniper stands in Nevada.

APPROACH: The entire above-stump biomass of randomly selected trees will be obtained for deadwood, green material larger than 3-inches diameter, and green material smaller than 3-inches. The proportions of foliage, twigs less than 1/4 in., branches 1/4-to 1-in., and branches 1-to 3-in. diameter will be determined by sampling. Representative disks and samples will be taken to the laboratory for oven-drying. Using various tree and site parameters, prediction equations will be developed for estimating resource potentials and quantity of fuel.

PROGRESS: Field work has been completed at 13 sample points located in various mountain ranges across Nevada. The sample includes aboveground biomass measurements for 50 pinyon and 28 juniper trees. Standard regression analysis techniques have been employed to determine which tree variable(s) can best estimate the biomass of the tree and also of the various size classes. For pinyon, diameter at stump height (DSH) was the best variable for estimating tree biomass ($R = .965$), followed by maximum crown diameter (CMax) ($R = .938$). Whereas for juniper, minimum crown diameter (CMin) was most predictive ($R = .924$), followed by DSH ($R = .913$). The double logarithmic (base e) equation resulted in the highest R values for estimating biomass. Most biomass prediction equations are based on stem measurements, stem diameter and height. Multiple regression analysis indicates that higher R values result when a crown variable is used in place of one of the stem variables. The biomass prediction equations will be utilized in the construction of weight tables designed for on the ground and aerial cruising in the P-J type.

SUPPORTED BY Nevada State Government

2.0170,

SILVICES AND SILVICULTURE OF SINGLELEAF PINYON AND UTAH JUNIPER

E.L. Miller, University of Nevada, Reno Campus, Agricultural Experiment Station, McIntire Stennis Program, *Reno, Nevada* 89507 (NEV00672)

OBJECTIVE: Determine natural regeneration requirements and the relationships of establishment and early growth to soil, site, and stand factors, determine relationships of biomass production, growth, and yield of stands, and develop principles and practices for the management and harvesting of p-j woodlands in Nevada.

APPROACH: The silvicultural aspects of regeneration and early growth will be determined by utilizing natural field seedlings, nursery seedlings, and greenhouse pot studies. Cone and berry production will be measured on selected trees and the establishment and survival of natural seedlings will be followed in regard to seedbed, aspect, and percent of cover. Selected seedlings will be measured for height, diameter, and age to determine the shade tolerance. selected seed lots will be tested for germination speed and percent and trials conducted on seedbed, germination, and storage requirements.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Nevada

2.0171,

EVALUATION OF TREE SPECIES FOR ENVIRONMENTAL AMELIORATION AND ENERGY PRODUCTION

E.L. Miller, University of Nevada, Reno Campus, Agricultural Experiment Station, Dept. of Renewable Natural Resources, *Reno, Nevada* 89507 (NEV00619)

OBJECTIVE: Develop recommendations for using tree species in the production of energy and to modify environmental conditions.

APPROACH: Tree plantings with a reasonable known history will be evaluated as to performance and cultural requirements; tree sub-stations which represent distinctly different climatic conditions will be selected and a species testing program initiated. Replicated plots will be used at each location to determine tree performance in regard to survival, growth, cultural requirements, and pest resistance.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Nevada

2.0172,

DECISION GUIDES FOR INTERMEDIATE SILVICULTURAL TREATMENTS

H.W. Hocker, University System of New Hampshire, Inst. of Natural & Environmental Resources, McIntire Stennis Program, *Pettee Hall, Durham, New Hampshire* 03824 (NH00010-M)

OBJECTIVE: Determine which designs of recording sheets and desk calculator methods are best suited for analysis of the following treatments in stands of small trees and multi-species mixtures: Weeding and thinning in northern hardwood stands, and thinning and pruning in white pine stands in New Hampshire. Test existing growth and yield functions, in physical and value units, for the stand types and treatments mentioned and improve these functions where gaps are found. Test a comprehensive decision-making computer program to select the most profitable timber improvement program for a specific stand, considering conditions of the forest, the owner's finances and objectives, and the market for products and services.

APPROACH: Basic methodology will be developed and integrated to provide a complete procedure for determining financial rate of return on timber stand improvement recommendations for a particular stand. Existing or new growth projection functions will be used to estimate future product yield and resulting cash flow. A process for selecting optimum thinning schedule, stand density and rotation length will be incorporated. Efficient methods for gathering stand and financial data will need to be developed and field tested. Remote terminal computer analysis of the entire process is anticipated.

PROGRESS: On the applied phase, 101 sample plots were established in twelve white pine study areas. After measurement and thinning, we found that the plots supported between 27-51 tons/acre of white pine stem-wood fiber; the 'B' line thinnings removed 12-14 tons/acre; the crop tree thinnings 8-16 tons/acre. Growth on a mean-annual-increment basis had been 0.75-1.50 tons/acre/year. Stands ranged from 23-48 years and measured 63-87 feet in site index. Volumes removed in thinning represent

wood which would be lost to mortality and which if cut and chopped could be used as supplemental fuel or for pulp. Total yield from thinning of whole trees would be greater than indicated since volumes cited are for stem wood w/bark only. In the basic phase, a biomass-nutrient project was completed and the equations for white pine, based on 23 trees ranging from 3.0 to 19.6 cm DBH, are: ln stem (g) = 4.274 2.269 ln DBH (cm); ln branch (g) = 1.733 2.656 1n DPH (cm); ln folaige (g) - 0.952 2.586 1n DBH (cm).
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, New Hampshire

2.0173,

COMPETITION FOR RURAL RESOURCES

D. Morris, University System of New Hampshire, Inst. of Natural & Environmental Resources, *Pettee Hall, Durham, New Hampshire* 03824 (NRE-43-322-33-01)

OBJECTIVE: Develop functional relationships for the supply of land to agriculture and among competing uses, relating land availability to commodity prices, commodity policies, resource policies, non-agricultural competing uses and other significant variables. Relate agricultural land availability to agricultural capacity and develop linkages between policy variables and the amount of land use and agricultural capacity.

APPROACH: Develop a system to account for land use changes over time as between agricultural uses, abandonment, reclamation, by irrigation or drainage, recreation, forestry, urbanization and surface mining. Use economic theory, models and statistical techniques to estimate functions relating land use for various purposes to explanatory variables. Using a regional definition system consistent with other projects and program areas of the division and of the Commodity Economics Division, estimate land supply among competing uses by region. In cooperation with other Division, intergrate land supply estimates with estimates of input supplies, yield projections and other measures of productivity to the capacity of agriculture.

PROGRESS: The year provided evaluations of the nature and extent of competition for rural resources from several sources. The actual withdrawal of land and water from agricultural production for surface mining will have rather minor consequences to agricultural output potentials. Preliminary analyses reveal the biomass energy could be competitive with returns from nonirrigated agricultural production at cost of about $3 per 10 BTU's. Without significantly increased costs of alternative energy sources, land and water use for biomass production are not economic at the present. Should biomass production become feasible, sizable amounts of land would be required. Research on the effects of urbanization and population growth on agriculture across the U.S. has revealed that each one percent increase in population density in urban areas is associated with a 1.05% increase in farmland values. Examination of the factors associated with groundwater irrigation development in the Central and Southern Plains have not reached any conclusions. The effects of energy prices and availabilities on these agricultural production systems are significant, however.

SUPPORTED BY U.S. Dept. of Agriculture, Economics Statistics & Cooperatives Service, Natural Resource Economics Div.

2.0174,

PYROLYSIS OF AGRICULTURAL RESIDUES AND FEEDLOT WASTES IN A REACTIVE STEAM ATMOSPHERE

M.J. Antal, Princeton University, School of Engineering & Applied Sciences, Dept. of Aerospace & Mech Science, *Box 430, Princeton, New Jersey* 08540 (B624B-538)

A program to investigate the pyrolysis of agricultural residues and feedlot wastes in a steam atmosphere is to be done. The program is motivated by the evident need to upgrade the energy value of organic wastes from them to become a nationally significant fuel resource. Hydrogen produced from solid wastes by steam pyrolysis could be used to meet a portion of the Nation's natural gas demand. Experimental work on the kinetics of steam pyrolysis is needed to design a practical reactor system and to establish the regimes where minimum levels of environmental pollutants are produced.

The research program outlined in this effort will investigate at the bench the effects of diverse parameters, e.g., heating rate and ultimate temperature, particle size, reactor residence time and pressure on steam pyrolysis. In addition, catalysis of the pyrolysis reactions and effects of trace constituents of the waste on catalysis will also be studied. Mathematical models based on differential equations describing the rate processes will be developed when appropriate. The research program is aimed at determining the optimal conditions for the production of a synthesis gas (composed primarily of H2, CO, and CO2) from organic wastes by steam pyrolysis. In order to achieve this goal, yields of char and liquid products will be minimized. Ultimate pyrolysis temperatures will also be kept as low as possible, but other conditions will be treated as true variables in the optimization process.

Results from this research will facilitate the design of a continuous, small-scale chemical reactor primarily for waste gasification, though some waste liquefaction information will also result.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Industrial Environmental Research Lab.

2.0175,

IMPROVED UTILIZATION OF WOOD (LIGNOCELLULOSE) THROUGH MICROBIOL GENETICS

D.E. Eveleigh, Rutgers the State University of New Jersey, New Brunswick Campus, Agricultural Experiment Station, McIntire Stennis Program, *Old Queens Bldg., New Brunswick, New Jersey* 08903 (NJ00504)

OBJECTIVE: Increase the potential of wood as a renewable base for the production of fuels and petrochemical substitutes through construction of a series of hyper-lignocellulolytic, catabolite repression resistant and end product inhibition resistant mutants of white rot fungi.

APPROACH: A series of selective plate screening assays will be developed to screen for hyperenzyme secreting mutants of white rot fungi for the enzymes involved in cellulose and lignin degradation. Mutant organisms will be characterized with emphasis on the role of cellobiose, quinone oxidoreductase as the key enzyme in the cometabolism of lignin and cellulose. Genetic crosses will be made utilizing the sexual stage of the fungus to improve strains and determine genetic linkages. Somatic cell hybrids will be obtained by protoplast fusion of white rot mutants as well as Trichoderma reesei mutants in a continuing effort to select superior lignocellulolytic strains.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, New Jersey

2.0176,

PRODUCING MUTANTS OF TRICHODERMA VIRIDE

D.E. Eveleigh, Rutgers the State University of New Jersey, New Brunswick Campus, School of Arts & Sciences, Dept. of Microbiology & Biochemistry, *Old Queens Bldg., New Brunswick, New Jersey* 08903 (E (49-18)-2539)

Economical production of glucose from cellulosic biomass can provide the basis for industrial fermentation products which substitute for petrochemicals. A key requirement is an inexpensive but highly active cellulase preparation. Trichoderma viride enzyme has been used by several groups developing processes for cellulose hydrolysis, and some improvements have been made through strain selection. Better procedures for mutation, screening, and testing should lead to significant cost reductions for preparing and using cellulase.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0177,

VALUE-ADDED OF SELECTED FOREST PRODUCTS IN NEW MEXICO

J.R. Gray, New Mexico State University, Las Cruces Campus, Agricultural Experiment Station, Mcintire Stennis Program, *University Park, Las Cruces, New Mexico* 88070 (NM00019)

OBJECTIVE: Measure value-added and factors associated with value-added in the timber, post, and fuelwood industries of New Mexico. Construct a model having predictive capabilities of value-added for the forest product industries of New Mexico.

APPROACH: Value-added will be determined from cost analysis and budgeting procedures for three major products--lumber, posts, and fuelwood. Stages to be analyzed will include forest management, harvesting, primary manufacturing, secondary manufacturing, transporting, and marketing at wholesale and retail. Lumber mills will be stratified by sizes, location, and information collected based on random samples and personal interviews with prepared questionnaires. Statistical analysis will be performed using stepwise regression and marginal correlation analysis to determine significant factors eventually used in predictive equations of value-added.

PROGRESS: Based on market values of forest products in New Mexico, value-added from sawmilling was $67 to $99 per thousand board feet in 1973, and from $58 to $87 in 1974, depending on size of mill. Value-added is the sum of wages and salaries, taxes, and profits or losses that occur as a product moves through various processes to consumption. As such it is a measure of the net contribution of an industry to a product, with the contribution based on market prices. Value-added was 44 percent of the retail price of lumber produced in New Mexico in 1973. By 1990, value-added of forest products is expected to increase to about $145 per thousand board feet, or add about five percent to the cost of housing each year for the next 15 years. The tax contribution of the wood products industry, including sawmilling, post production, and firewood harvesting, was much larger than anticipated, being approximately 15 percent of the total value-added. Taxes were largest at the retail and sawmilling or manufacturing stages. With growing concern about environment, food supplies, recreation, energy, and conservation, the value-added concept is useful in estimating benefits and costs of changes in priorities in using federal multi-purpose forest resources.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, New Mexico

2.0178,

ECONOMIC CHARACTERISTICS OF FUELWOOD HARVESTING IN NEW MEXICO

J.R. Gray, New Mexico State University, Las Cruces Campus, Agricultural Experiment Station, Mcintire Stennis Program, *University Park, Las Cruces, New Mexico* 88070 (NM00020MS)

OBJECTIVE: Determine fuelwood supplies, present and predicted, by species by key and harvested supply areas of New Mexico; measure investments and costs of fuelwood harvesting by both dealers and consumers harvesting their own wood; ascertain the socio-economic characteristics of fuelwood users, and construct fuel energy budgets indicating net gains or losses in harvesting fuelwoods in various areas.

APPROACH: Data from Federal Forest Service and State Forestry dealing with fuelwood supplies and harvests will be tabulated and related to fuelwood management policies. Historical trends in fuelwood production and use will be determined from published data, and projected to 2000. Individuals issued cutting permits will be tabulated, a sample drawn and a mail questionnaire sent to the selected samples. Personal interviews will be made of chainsaw dealers. The mail questionnaire will deal with investments, costs, and fuel uses as well as socio-economic characteristics and characteristics of wood burning units. Analyses will include statistical projections of supply and demand, and cost and energy budgets.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, New Mexico

2.0179,

SEWAGE AND REFUSE AS ENERGY SOURCES

E.E. Staffeldt, New Mexico State University, Las Cruces Campus, School of Arts & Sciences, Dept. of Biology, *University Park, Las Cruces, New Mexico* 88003

DESCRIPTION: Numerous problems are focusing on the handling and treatment of sewage, garbage, cotton gin trash and food processing plant wastes. The organic materials in these residues are important sources of energy which are not being utilized, but are costing substantial amounts of money for disposal. This work incorporates the use of enzyme and microbial generators which will be employed to convert cellulose, hemicellulose, and lignin into simple soluble substances (primarily sugars) which can be harvested or further converted into ethyl alcohol and/or methane. Enzyme generators are to be developed and utilized instead of living cells for certain degradative processes to insure rapid conversion of large amounts of refuse. Development of a continuous fermentative system is described. Gasoline-ethyl alcohol mixtures with appropriate additives and engine settings will be tested in internal combustion engines to determine the feasibility of using mixtures to expand the present fuel supply.

SUPPORTED BY New Mexico State Government

2.0180,

COMBUSTION STUDIES OF ALTERNATE FUELS

K.C. Hoffman, Brookhaven National Lab., *Upton, New York* 11973 (082408 (HRB NO.))

Alternate fuels combustion is being studied at a fundamental scientific level to obtain information on the elementary chemical and physical phenomena occuring in practical combustion devices such as I.C. engines. Techniques involve in situ emission spectroscopy, chemical analysis of combustion products, and mathematical modeling of combustion phenomena. Fuels studied include: methanol, ethanol, hydrogen, and non-petroleum derived gasolines. /BNL/

SUPPORTED BY U.S. Dept. of Energy, Div. of Basic Energy Sciences

2.0181,

CONVERSION OF ORGANIC WASTES TO OIL

L.G. Donaruma, Clarkson College of Technology, School of Arts & Sciences, Dept. of Chemistry, *51 Main St., Potsdam, New York* 13676

DESCRIPTION: This research converts solid wastes of all types of oil. It has been found that any organic material can be converted into a basic fuel oil (No. 6) of low sulphur content. This oil also can be cracked to form gasoline and kerosene type hydrocarbon mixtures. The chemistry of the system has been isolated and characterized in detail. A miniaturized pilot plant is under construction.

ADDENDA: Estimated calendar year funding reported as 1975 $35,000.

SUPPORTED BY Eastman Kodak Co.

2.0182,

PRODUCTION OF SYNTHESIS GAS FROM COAL & MUNICIPAL SOLID WASTE - THE SIMPLEX MOVING BURDEN GASIFIER

H.W. Schulz, Columbia University, School of Engineering, Dept. of Chemical Engin, *351 Engineering Ter., New York, New York* 10027 (EF-77-S-01-2713)

The broad objective is to develop a slagging moving-burden gasifier of high productivity capable of processing caking coals and coal fines. A key feature of the Simplex process is the compacting or briquetting of the burden which comprises a well blended mixture of an Eastern bituminous caking coal encapsulated in shredded municipal solid wastes, biomass, or lignite. The specific objective of the Phase I-C research and development program is to define the effect of the briquette formulation and fabrication parameters on the structural integrity and caking propensity of pre-formed Simplex briquettes in the drying, pyrolysis, and reaction zones of the gasifier. The parameters being evaluated include type and particle size of coal, form of MSW or refuse-derived fuel, the coal/MSW ratio, choice of low-cost binder (if any), compaction pressure, and briquette size. Another specific objective is to determine heat transfer, drying, and relative reaction rates of Simplex briquettes at temperature levels from 300 to 3000 degrees F. A bench-scale model with a throughput capacity of 2 tons per day was successfully operated with a charge of 1 : 1 Simplex briquettes and a slagging hearth temperature of 3000 degrees F without any evidence of agglomeration, bridging, or channelling. The process is ready for pilot plant development in a 10 tpa slagging gasifier, which has been made available to the project.

SUPPORTED BY U.S. Dept. of Energy, Office of Fossil Energy

2.0183,

ALGAL CONCENTRATION BY ULTRAFILTRATION

H.P. Gregor, Columbia University, School of Engineering & Applied Science, Dept. of Chemical Engin & App Chemistry, *Broadway & W. 116th St., New York, New York* 10027 (E(11-1)-4076)

Microalgae can be a prime candidate for obtaining high yields of biomass, but collection and harvesting are too expensive. In the past the concentration of algae by ultrafiltration has been impractical because of membrane fouling. The evaluation of new non-fouling ultrafiltration membranes with algae constitutes the novel aspect of this program. A number of different algal suspensions will be concentrated employing new ultrafiltration membranes of a fixed-charge (sulphonic acid) type. Algal suspensions will be concentrated in the laboratory, employing membranes of different porosities and examining the use of different pressures and rates of recirculation to achieve different degrees of concentration. Following this, a small bench-scale pilot plant device will be installed at an appropriate field installation with selected algal cultures to study the operation of the system under field conditions, using membranes which have been selected on the basis of the laboratory study. (ERDA 76-137)

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0184,

BIOCONVERSION OF AGRICULTURAL WASTES FOR ENERGY CONSERVATION AND POLLUTION CONTROL

W.J. Jewell, Cornell University, Ithaca Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Ithaca, New York* 14850 (NYC-123321)

OBJECTIVE: Determine the overall feasibility of using anaerobic digestion of agricultural organic wastes to provide an energy source for agricultural operations while reducing and controlling pollution. Factors to be determined for a 60 cow dairy operation and a 1000 head beef feedlot operation will include: total energy needs of the production operation, net energy available from methane generation after the energy requirements of the process are deducted, opportunities to use net energy, manpower requirements, waste handling and residue disposal alternatives, and economic implications.

APPROACH: Use a multi-disciplinary approach to conduct a study with known or easily synthesized data to determine the feasibility of organic conversion to an energy source. The approach will not be to demonstrate again that methane can be generated from organic wastes. Important areas such as the following: overall contribution of waste handling process to well-being of agriculture and to envoronmental quality, availability of equipment and technology, detailed disposition of processed waste materials, and net cost of energy production and polluting control.

PROGRESS: The feasibility of utilizing anaerobic fermentation processing of animal waste in dairies and beef feedlots for the purpose of pollution control and energy generation is being determined. This study emphasizes the 40 and 100 cow dairy herds and the 1000 head beef feedlot. Detailed energy consumption patterns were developed for these types of operations. The availability of anaerobic fermentation equipment and the state-of-the art of this technology are also included in this feasibility study. Detailed systems are designed and costed for these agricultural operations. Finally, the value of the methane energy that can be consumed in dairies and feedlots is estimated. This study terminates December 31, 1975. It is expected that the final report will be available from the U.S. Energy Research and Development Administration (U.S. E.R.D.A.) in the first half of 1976.

SUPPORTED BY New York State Government

2.0185,

ANAEROBIC FERMENTATION OF AGRICULTURAL WASTES - POTENTIAL FOR IMPROVEMENT AND IMPLEMENTATION

W.J. Jewell, Cornell University, Ithaca Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Ithaca, New York* 14850 (NYC-123360)

OBJECTIVE: Determine the potential for optimizing technology related to anaerobic fermentation of agricultural wastes; identify fermentor designs capable of more rapid or more efficient recovery of energy containing by-products of gas, nutrients and solid residues, and to demonstrate the feasibility of improved fermentors using small laboratory models followed by large scale pilot plants. Studies will be conducted with dairy cow wastes.

APPROACH: This study will be divided into 3 major efforts -identification of improved fermentor designs using small scale laboratory models, definition of optimized fermentor designs, and demonstration of new process feasibility in large scale pilot plants. Two general concepts will guide the development of future optimized anaerobic fermentation technology: Simplistic operation involving minimal manpower and the elimination of the waste by production of useful energy-containing by-products. The focus will be on the transformation of a 'waste' into useable but currently unrecovered energy-containing by-products. The Cornell study has identified two unique anaerobic fermentation system designs: One could be capable of operation with the simplest of demands on the farm; whereas a complex unit may accomplish stabilization, methane production, liquid-solids separation and pathogen destruction in one unit operation.

PROGRESS: The main goals of this multi-disciplinary project are to identify new types of anaerobic fermentors that could generate gas at lower cost or more rapidly and efficiently than can be accomplished using existing technology, and to define the social and economic needs to implement this technology in agricultural systems. Presently, 10 anaerobic fermentors varying in size from 8 liters to 5000 liters are being operated. The major fermentor variables which are under study are: mixing, temperature, solids concentration, and reaction period. Efforts to separate the viable bacteria to increase the reaction rates are also included. The digester influent and effluents are also being characterized by animal feed nutrient analysis, bacterial enumeration for major groups, and dewaterability. Other on-going studies include development of economic and societal perception surveys.

SUPPORTED BY New York State Government

2.0186,

PHOTOSYNTHETIC ENERGY CONVERSION

R.K. Clayton, Cornell University, Ithaca Campus, School of Biological Sciences, Dept. of Physiology, *Ithaca, New York* 14850

Physical and chemical processes of photosynthesis will be studied using optical techniques applied to photosynthetic membranes and photochemical reaction centers isolated from photosynthetic bacteria. Work will be extended on the events in reaction centers that begin with the absorption of light by bacteriochlorophyll (BChl) and bacteriopheophytin (BPh) and culminate in the formation of oxidized BChl and reduced ubiquinone, passing through a transient state in which an electron has apparently been displaced from BChl to BPh. To define the participation of the different chromophores and the properties of the transient state, the fluorescence from BChl and BPh at low temperatures and measure action spectra from these fluorescences and for photochemistry will be studied. A variety of measurements of optical absorbance transients and fluorescence will be made with polarized light to reveal the relative orientations of chromophores in the reaction centers and in the intact photosynthetic membrane. Unresolved questions as to the identity of the primary electron acceptor in reaction centers from various species of photosynthetic bacteria will be approached by studying the effects of extraction and replacement of quinones and related compounds. Possible misinterpretations due to the introduction of artificial reactions will be explored with reaction centers that have been rendered inactive and then restored to photochemical activity by various chemical treatments and illumination programs. The role of water in the functioning of reaction centers by observing the consequences of removing water and of then adding H2O, D2O, other solvating agents, etc will be investigated. It has been shown that purified reaction centers can be mixed with purified 'antenna' pigment-protein from photosynthetic membranes in such a way that energy transfer is restored. This system will be further exploited to delineate the flow of excitation energy between antenna pigments and reaction centers in the living cell. Also an attempt will be made to build a solar battery from these materials.

SUPPORTED BY U.S. National Science Foundation, Div. of Physiology Cellular & Molecular Biology

2.0187,

BIOCONVERSION OF AGRICULTURAL WASTES FOR ENERGY CONSERVATION AND POLLUTION CONTROL

W.J. Jewell, Cornell University, Ithaca Campus, School of Engineering, Dept. of Agricultural Engineering, *242 Carpenter Hall, Ithaca, New York* 14850 (E(11-1)-2981)

This study will be divided into three major efforts: (1) identification of improved fermentor designs using small-scale laboratory models; (2) definition of optimized fermentor designs; and (3) demonstration of new process feasibility in large-scale pilot plants. Two general concepts will guide the development of futre optimized fermentation technology: (1) simplistic operation involving minimal manpower and (2) the elimination of the waste by production and useful energy-containing by-products. The focus will be on the transformation of a "waste" into usable but currently unrecovered energy-containing by-products. The Cornell study has identified two unique anaerobic fermentation system designs. One could be capable of operation with the simplist of demands on the farm; the other, a complex unit, may accomplish stabilization, methane production liquid-solids sepa-

ration and pathogen destruction in one unit operation. (ERDA 76-137)
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0188,
BIOCONVERSION OF PLANT BIOMASS TO ETHANOL

H.W. Lake, General Electric Co., *1 River Rd., Schenectady, New York* 12305

Economical production of ethanol from cellulosic biomass would significantly reduce our needs for petroleum. This project will strive for an all-biological process consisting of the following steps: (1) novel high-solids pretreatment with a thermo-tolerant mold to remove lignin; (2) mixed culture fermentation for simultaneous cellulose hydrolysis and ethanol production; and (3) ethanol recovery. Lignin degradation is carried out by an interesting organism which functions well in semi-solid media and poorly in liquid suspension. Attack on lignin continues after growth is halted by raising the temperature. Development of the mixed culture ethanol fermentation will consider physical and chemical parameters and will test various ratios of inocula. There will be studies of reactor design and process scale-up.
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0189,
APPLICATION OF 'RAPID FERMENTATION' TO THE PRODUCTION OF PRODUCTS FROM CELLULOSIC WASTES

K.H. Steinkraus, New York State Agricultural Experiment Station, *Geneva, New York* 14456 (NYG23363)

OBJECTIVE: Apply the principles of 'rapid fermentation' to the practical production of cellobiose and/or glucose from cellulosic substrates, particularly wastes such as straw, waste paper, and sawdust. Utilize the cellobiose/glucose directly in the manufacture of useful fermentation products.
APPROACH: Trichoderma viride, Cellulomonas sp., Myrothecium sp., Chaetomium sp., Neurospora crassa all cellulase producers, will be applied to crude cellulose substrates including straw, waste paper, and other cellulosic wastes. The 'rate' i.e., the number of glucose molecules produced from the cellulose per cell (or per unit cell weight) per second will be determined. Then the number of cells required to produce the rate of reaction desired will be determined. Then the % of total available cellulose hydrolyzed in a given time interval will be determined. Present processes for cellulose hydrolysis require generally several days making the use of cellulose rather impractical. Initially, the objective will be to reduce fermentation time to less than 24 hours and then to reduce the total time required to 10 hours or less.
PROGRESS: Molds growing on filter paper during seed germination were isolated and identified. They were then inoculated into 500 ml Erlenmeyer flasks containing 200 ml of medium. 1% solka-floc (purified wood cellulose) was the carbohydrate included as an energy source for the microorganisms. Other ingredients in the medium included: 0.2% KH(2)PO(4); 0.14% (NH(4))(2)SO(4); 0.03% urea; 0.1% proteose peptone; 0.1% Tween 80 and mineral salts. The medium was adjusted to pH 5. The cultures were shaken on an incubated New Brunswick shaker at 25 C for days. The solids consisting of residual cellulose and mold mycelium were recovered by centrifuging. The solids were then thoroughly washed to remove residual solubles and inorganic nitrogen. Semi-micro Kjeldahl analysis showed that the crude protein content of the cellulose/mycelium mixtures (using a 6.25 conversion figure) had reached 30.6% using the mold Sclerotinia, 26.9% using the mold Myrothecium, and 14.4% using Neurospora crassa.
SUPPORTED BY New York State Government

2.0190,
CONVERSION OF SOLID WASTE FROM GRAPES AND APPLES TO DIRECTLY UTILIZABLE HEAT ENERGY

R.H. Walter, New York State Agricultural Experiment Station, *Geneva, New York* 14456 (NYG23356)

OBJECTIVE: Study the conversion of the chemical energy existing in apple and grape pomace into economical, directly utilizable heat.
APPROACH: The physical-chemical Croperties of apple and grape pomace will be studied, in order to ascertain the factors conducive to the manufacture of briquets. The data obtained will provide the scientific-technical input into the engineering and construction of briquet manufacture.
PROGRESS: Dried apple pomace and grape pomace were combusted calorimetrically, and were found to contain 8000 and 8400 BTU per lb., respectively. These values were approximately 60-65 percent of the combustion energy of commercial charcoal briquettes (12800 BTU per lb) and sawdust fire logs (14000 BTU per lb.). When the pomace was subjected to peroxide treatment and pyrolyzed at 200 -250 before combustion, the BTU per lb. increased to 11500.
SUPPORTED BY New York State Government

2.0191,
CONTINUOUS TWIN SCREW ACID HYDROLYSIS REACTOR DEVELOPMENT AND OPTIMIZATION FOR ONE-TON DAY WASTE CELLULOSE GLUCOSE PILOT PLANT

W. Brenner, New York University, School of Arts & Sciences, Dept. of Applied Science, *421 1st Ave., New York, New York* 10012 (C624B-7043)

Solid waste is now recognized as both a major problem and a underutilized renewable resource for materials and energy recovery. While acid hydrolysis of waste cellulose is potentially very attractive because cheap glucose would be a most useful intermediate for chemicals and energy production, technical problems such as low glucose yields and long reaction times have prevented large scale usage. Experiments carried out over the last two years at New York University have demonstrated that selected pretreatment of cellulosic wastes followed by a rapid high temperature acid hydrolysis can readily produce glucose yields in the order of 50 per cent based on the available cellulose content. Exploratory studies have also been performed with a continuous twin screw acid hydrolysis reactor. The results strongly support the technical and economic viability of this type of continuous reactor for carrying out large scale conversion of waste cellulose to glucose.
A 3 year program of experimental investigations is herewith proposed on the additional development and optimization of the continuous twin screw acid hydrolysis reactor for the establishment and operation of a one-ton/day waste cellulose-glucose pilot plant. This program encompasses: 1) the identification of all pertinent acid hydrolysis equipment; 2) procurement and installation; 3) optimization of operating conditions including waste cellulose feed preparation and glucose recovery; 4) product quality analysis' and 5) determination of environmental impact with maximum energy conversion. For most effective utilization of time and money, a previously evaluated twin screw machine will be leased on an annual basis for the acid hydrolysis reactor. Initial optimization will be carried out with waste newspapers. The experimental work will be supplemented by a detailed economic cost analysis with subsequent projections for various larger production scale-ups.
SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Municipal Environmental Research Lab.

2.0192,
ECONOMIC FEASIBILITY AND POTENTIAL OF PRODUCING AND USING ALCOHOL BLENDS IN NEW YORK STATE

W. McShane, Polytechnic Inst. of New York, Brooklyn Campus, School of Science & Engineering, Dept. of Transportation Plan & Engin, *333 Jay St., Brooklyn, New York* 11201 (177836 (HRB NO.))

To perform an assessment of the economic feasibility of producing various alcohols (methanol, ethanol, etc.) to be blended with gasoline and used as a fuel in existing automobiels (i.e. without any mechanical adjustments). The project will review distillation technologies. Sources of biomass, raw materials, interaction with petroleum producers and retailers, and acceptance of blended fuel by public. A workshop/seminar on this concept will be run, including quests from industry, government, and academia.
SUPPORTED BY New York State Government

2.0193,
ELECTRON TRANSPORT AND OXYGEN EVOLUTION IN PHOTOSYNTHESIS

J.T. Warden, Rensselaer Polytechnic Inst., Graduate School, Dept. of Chemistry, *110 8th, Troy, New York* 12181 (7800121)

OBJECTIVE: Characterization of the chemical reactants involved in the transformation of solar energy into oxidative potential for water splitting; elucidation of intemediates associated with the manganoenzyme catalyst of oxygen evolution; identification of regulatory properties for ATP formation associated with Photosystem 2.
APPROACH: The methodology for this project includes kinetic analysis of Photosystem 2 by laser flash-photolysis electron spin resonance, oxygen evolution and phosphorylation determinations of spinach chloroplasts.
SUPPORTED BY U.S. Dept. of Agriculture

2.0194,
FUELS AND PETROCHEMICAL SUBSTITUTES FROM FERMENTATION OF BIOMASS

D. Hansen, Rensselaer Polytechnic Inst., School of Engineering, Dept. of Chemical & Environ Engin, *110 8th St., Troy, New York* 12181 (EG-77-G-01-4001)

Projects on bioconversion of plant biomass to fuels or petrochemical substitutes are coordinated by means of contractor conferences, visits, phone conversations, and review of reports. Pending proposals are evaluated, and site visits are performed for those projects with likelihood of approval to inspect facilities and to insure that the research group has the required competence and appreciation of the problems. Contractors are supported by independent cost evaluations, library searches, and engineering projects which are published in a newsletter. Salient features of contractor results are also in the newsletter. Contractor references include constructive criticism, integration of research, and mutual planning.
SUPPORTED BY U.S. Dept. of Energy

2.0195,
FERMENTATION INTERACTIONS IN MICROBIAL ECOSYSTEMS

M.J. Wolin, State Div. of Lab. & Research, Environmental Microbiol Sect, *Empire State Plaza, Albany, New York* 12237

Pure cultures will be studied singly and in combination to elucidate how organisms interact to produce characteristic fermentations of complex, anaerobic, microbial ecosystems. The studies will focus on mammalian gastro-intestinal fermentations and anaerobic waste decomposition. Previous investigations showed that H2-using species can increase formation of H2 and alter fermentation products of major saccharolytic rumen species. These studies will be extended to other H2-producing saccharolytic species of the rumen, the human large intestine and to organisms that produce H2 from non-carbohydrate sources. Interactions between cellulose- or starch-hydrolyzing species and non-polymer fermenting species will be examined. The latter organisms use soluble sugar intermediates produced from the polymers. catalogue of species capable of interaction will be prepared and the amount of competition for hexose will be estimated. Models of the various ecosystem fermentations will be prepared by mixing selected pure cultures. To model the systems that completely convert organic carbon to CH4 and CO2, the nutrition of the only pure culture known to convert acetate to CH4 and CO2 will be studied, and isolation of new species will be undertaken. Changes in growth rate, controlled by limiting carbohydrate in a chemostat, markedly change the fermentation products of certain bacteria by affecting paths of pyruvate catabolism. Studies will be extended to other species with alternate paths of pyruvate catabolism to examine the generality of the phenomenon. The questions of whether limiting nutrients other than carbohydrates will produce the same effects and whether control of pathways is pre- or post-translational will be examined. Growth rate-fermentation product relationships may be an important feature of ecosystem activity. Studies will be continued of electron transport systems that are significant in the production of H2 by organisms whose fermentations are influenced by H2.
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SUPPORTED BY U.S. Dept. of Health Education & Welfare, Public Health Service, National Inst. of Health, National Inst. of Allergy & Infectious Diseases

2.0196,

PHOSPHORUS SOLUBILIZATION DURING ANAEROBIC DECOMPOSITION OF ALGAE

A.C. Middleton, State University of New York, Buffalo Campus, Graduate School, *1300 Elmwood Ave., Buffalo, New York* 14222

The objective of this research project is to investigate the significance of sulfate-reduction in making phosphate soluble. Experiments are planned to evaluate the differences in phosphate solubilization among anaerobic decomposition of algae cells by sulfate-reduction, by nitrate reduction (denitrification) and by methane fermentation.

Enriched cultures of mixed algal populations will be developed in laboratory scale, continuous-flow reactors. These cultures will then be allowed to undergo anaerobic decomposition at controlled temperatures in laboratory scale, batch reactors. Concentrations of various parameters including soluble phosphate and iron will be monitored with time for each of the three modes of anaerobic decomposition i.e sulfate reduction, nitrate reduction, and methane fermentation.

The results of this project are expected to provide a better understanding of the significance of sulfate reduction in phosphate solubilization. Experimental results will be compared with expected results based on chemical models.

SUPPORTED BY U.S. National Science Foundation, Div. of Engineering

2.0197,

RESEARCH INITIATION - MICROBIAL PRODUCTION OF ETHANOL FROM SOLVATED CELLULOSIC WASTES

D.W. Zabriskie, State University of New York, Buffalo Campus, School of Engineering & Applied Science, Dept. of Chemical Engin, *3435 Main St., Buffalo, New York* 14214

This research concerns the examination of a two-step process directed at the economic conversion of cellulosic waste materials to ethanol. The first stage entails solvation of the cellulose resulting in a soluble derivative, which is then hydrolyzed and converted to ethanol through the mediation of suitably selected yeasts in the second stage. The appealing characteristic of the present two-stage process derives from the fact that it exploits the hydrolyzing action of the cellulase enzymes in the more desirable homogeneous reaction phase, and replaces the slower enzymatic crystal disruption process with the more rapid chemical solvation.

SUPPORTED BY U.S. National Science Foundation, Div. of Engineering

2.0198,

LOW TEMPERATURE, CRITICAL PRESSURE, WATER/STEAM GASIFICATION

J.A. Coffman, Wright Malta Corp., *Ballston Spa, New York* 12020 (E(11-1)-4124)

The objective of this project is to study the feasibility of gasification of biomass to produce a fuel gas in a small scale critical pressure (3200 psi), low temperature (1110 degrees F) water/steam gasifier. A low-cost system has been proposed and the laboratory work is required to verify the reactions and the possibilities of using the process on all types of biomass from grass to wood chips.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0199,

STEAM GASIFICATION OF WASTE AND BIOMASS

J.A. Coffman, Wright Malta Corp., *Ballston Spa, New York* 12020

There are two related projects: (1) Develop a rotary kiln gasifier-gas turbine generator system for conversion of solid and liquid waste into electric power. Work to date in a minikiln has proven in the gasification chemistry. Mechanical development would be completed in a proposed pilot plant. (2) Develop process equipment for conversion of biomass into medium Btu fuel gas. Work in a continuous research gasifier has shown clean, complete steam gasification of sawdust. A pilot plant is being designed.

ADDENDA: This project is also supported by: Environmental Protection Agency; Empire State Electric Energy Research Corp.; and Wright-Malta, Inc.

SUPPORTED BY U.S. Dept. of Energy, Div. of Conservation Research & Technology

2.0200,

THERMOPHILIC METHANE PRODUCTION FROM POULTRY WASTE

J. Shih, University of North Carolina, North Carolina State University, Agricultural Experiment Station, Dept. of Poultry Science, *Raleigh, North Carolina* 27600 (NC03605)

OBJECTIVE: Isolation and selection of a methanogenic bacterial culture in a poultry waste-based medium at thermophilic temperatures; adaptation of the methanogenic culture to a highly efficient methane producer and chemical analyses to fully characterize the wastes, the gas products, and the effluents from the reactor.

APPROACH: A number of cultures of thermophilic bacteria will be screeened to identify the strains that have the capability of producing large volumes of methane from poultry waste. Preliminary laboratory studies will be conducted to purify the strains and perfect the methane generation.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, North Carolina

2.0201,

AN INTEGRATED APPROACH TO THE CONVERSION OF LIGNOCELLULOSE FROM WOOD INTO USEFUL CHEMICALS

I.S. Goldstein, University of North Carolina, North Carolina State University, School of Forest Resources, Dept. of Wood & Paper Science, *Raleigh, North Carolina* 27607

Synthetic organic materials derived from petroleum play an indispensable role in our economy in the form of adhesives, electrical insulation, fibers, plastics and rubbers. The increasing cost of petroleum as well as its ultimate depletion make the substitution of a renewable resource such as biomass for petroleum as a raw material a desirable objective. Wood is the most important component of this renewable biomass with forests being responsible for two-thirds of all dry matter being produced on land. The conversion of wood into chemicals for the production of most of our synthetic plastics, fibers and rubbers is technically feasible. Intermediates include ethyl alcohol (which can be further processed to ethylene and butadiene), phenols and furfural. However, further technical effort is needed to improve the economics of the chemical conversion of wood. The objectives of this project are to study the conversion of the wood components (hemicelluloses, cellulose and lignin) from low-quality southern hardwoods to useful chemicals in a systematic integrated manner and to specifically explore promising avenues in prehydrolysis, high energy electron beam radiation to increase the accessibility of cellulose to hydrolysis by strong hydrochloric acid, and the hydrogenation of the derived lignin to phenols.

SUPPORTED BY U.S. National Science Foundation, Div. of Advanced Energy & Resources Research & Technology

2.0202,

HYDROGEN-PRODUCING BACTERIA IN ANAEROBIC WASTE TREATMENT

P.E. Holmes, North Dakota State University, Agricultural Experiment Station, Dept. of Bacteriology, *Fargo, North Dakota* 58103 (ND01811)

OBJECTIVE: Identify hydrogen-producing bacteria in anaerobic waste treatment; define parameters affecting hydrogen-producing bacteria; determine the importance of hydrogen-producing bacteria in anaerobic waste treatment.

APPROACH: In situ rates of hydrogen generation and turnover will be estimated as a function of factors known to influence waste treatment. Direct isolation and characterization of anaerobic bacteria from wastes being treated anaerobically. Ability to produce hydrogen will be assessed, using growth conditions that closely simulate the habitat of an anaerobic digester. Parametric study of pure culture isolates that will consider factors known to influence anaerobic treatment. Such parameters will include pH, temperature, substrate types and concentrations, oxygen and redox potential, organic and inorganic substances other than substrates and components of the waste.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, North Dakota

2.0203,

PSYCHROPHILIC ANAEROBIC WASTE TREATMENT IN NORTHERN CLIMATES

P.E. Holmes, North Dakota State University, Agricultural Experiment Station, Dept. of Bacteriology, *Fargo, North Dakota* 58103 (ND05080)

OBJECTIVE: Seasonal effects on occurrence and activity of psychrophilic and psychrototrophic bacteria in anaerobic waste lagoons; parameters of growth and activity of psychrophilic and psychrotrophic anaerobic bacteria; study laboratory scale low temperature anaerobic digesters; determine effectiveness of seeding conventional lagoon models with psychrophilic and psychrotrophic anaerobic bacteria in relation to operating temperature; assess potential for methane recovery from low temperature anaerobic lagoons.

APPROACH: Lagoon samples are cultured directly on selective and non-selective media at various temperatures to assess numbers and types of bacteria and correlated with physical-chemical parameters of the lagoon. The Hungate anaerobic technique used; isolates with temperature optima below 20 C will be further characterized; laboratory scale digesters will be discontinuously fed typical lagoon feed and operated at various temperatures; seeding studies will monitor methanogenesis, waste turnover and seed growth; zero-time rates of methanogenesis will be used to assess potential for methane production and digestion rates.

PROGRESS: Laboratory-scale digesters containing 3-1 of hog lagoon water and fed raw hog waste at different rates while operated at different temperatures are being studied to determine if anaerobic psychrophilic bacteria develop at low temperatures. Direct viable counts on selective and nonselective culture media suggest an enrichment of psychrophiles may be occurring but the data are insufficient in amount to be unequivocal. Other evidence for possible enrichment includes a slight downward shift in the temperature optimum for methanogenesis by digester samples. These effects were noted over a 9-month period of digester operation.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, North Dakota

2.0204,

NON-PETROLEUM FUELS FOR POWER UNITS USED BY AGRICULTURE

K.R. Kaufman, North Dakota State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Fargo, North Dakota* 58103 (ND01437)

OBJECTIVE: Evaluate the use of non-petroleum fuels such as ethyl alcohol, methyl alcohol and methane for internal combustion engines.

APPROACH: Tractor engines will be tested in the laboratory to determine the effects of substituting alcohol-fuel mixtures for tractor fuel. Both gasoline and diesel engines will be studied. Road tests will be made with automobiles to determine the effects of substituting gasoline-alcohol blends for gasoline. In all tests, comparisons will be made between the energy content of the alcohol-fuel blend and the fuel consumption of the engine. Next, engines will be modified and evaluated for performance and emissions while using alcohol-fuel blends.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, North Dakota

2.0205,

COOPERATIVE INVESTIGATIONS IN AGRICULTURAL BIOCHEMISTRY

H.J. Klosterman, North Dakota State University, Agricultural Experiment Station, Dept. of Biochemistry, *Fargo, North Dakota* 58103 (ND03201)

OBJECTIVE: Provide a means for cooperative work of a service on preliminary nature between biochemistry and other departments of the experiment station.

APPROACH: Laboratory work and consultation as needed.

PROGRESS: Estrogens were not detected in Zea mays tassels at the meiotic or immediate postmeiotic stages. The principle sterols in the male sterile (Texas type) and restored were sitosterol, stigmasterol and campesterol, with small amounts of cholesterol, isofucosterol, trine 7-stigmastenol and 24-methylene cholesterol. Male sterile tassels contain less free sterols than the restored genotype. Application of cholesterol-4-C14 to the leaves resulted in translocation of free cholesterol to the tassels. The economics of the production and use of grain alcohol as a motor fuel were reviewed. Present technol-

ogy requires the use of more energy to produce alcohol than can be obtained by burning alcohol as a fuel. Raw materials costs results in a high-cost for grain alcohol. It is concluded that cereal grains should not be considered as a source for alcohol for motor fuel.
SUPPORTED BY North Dakota State Government

2.0206,
COMPETITION FOR RURAL RESOURCES
W. McMartin, North Dakota State University, U.S. Dept. of Agriculture Natural Resources Economics Div., *Fargo, North Dakota* 58103 (NRE-43-322-38-01)
OBJECTIVE: Develop functional relationships for the supply of land to agriculture and among competing uses, relating land availability to commodity prices, commodity policies, resource policies, non-agricultural competing uses and other significant variables. Relate agricultural land availability to agricultural capacity and develop linkages between policy variables and the amount of land used and agricultural capacity.
APPROACH: Develop a system to account for land use changes over time as between agricultural uses, abandonment, reclamation, by irrigation or drainage, recreation, forestry, urbanization and surface mining. Use economic theory, models and statistical techniques to estimate functions relating land use for various purposes to explanatory variables. Using a regional definition system consistent with other projects and progress areas of the Division and of the Commodity Economic Division, estimate land supply among competing uses by region. In cooperation with other Divisions, integrate land supply estimates with estimates of input supplies, yield projections and other measures of productivity to the capacity of agriculture.
PROGRESS: The year provided evaluations of the nature and extent of competition for rural resources from several sources. The actual withdrawal of land and water from agricultural production for surface mining will have rather minor consequences to agricultural output potentials. Preliminary analyses reveal the biomass energy could be competitive with returns from non- irrigated agricultural production at a cost of about $3 per 10 BTU's. Without significantly increased costs of alternative energy sources, land and water use for biomass production are not economic at the present. Should biomass production become feasible, sizable amounts of agriculture across the U.S. has revealed that each one precent increase in population density in urban areas is associated with a 1.05% increase in farmland values. Examination of the factors associated with groundwater irrigation development in the Central and southern Plains have not reached any conclusions. The effects of energy prices and availabilities on these agricultural production systems are significant, however. In studies of land conversion potentials in the southeast, it is revealed that topography, soil type, and fertility are important physical characteristics affecting land use.
SUPPORTED BY U.S. Dept. of Agriculture, Economics Statistics & Cooperatives Service, Natural Resource Economics Div.

2.0207,
INVESTIGATE GASIFICATION METHODS FOR CONVERSION OF FOREST RESIDUE TO METHANE-RICH GAS USING CHEMICALLY INCORPORATED CALCIUM OXIDE CATALYST
H. Feldmann, Battelle Memorial Inst., Columbus Laboratories, *505 King Ave., Columbus, Ohio* 43201 (W-7405-ENG-92-002)
No summary has been provided to the Smithsonian Science Information Exchange.
SUPPORTED BY U.S. Dept. of Energy

2.0208,
ENVIRONMENTAL AND TECHNOLOGICAL ANALYSIS OF THE USE OF SURPLUS WOOD AS AN INDUSTRIAL FUEL
E.H. Hall, Battelle Memorial Inst., Energy Syst & Environ Res Sect, *505 King Ave., Columbus, Ohio* 43201 (B624B-546)
There is a widespread interest in the use of surplus wood as an industrial fuel because it does not contain sulfur, it is a renewable resource, and the technology for its use is available. There are, however, some unresolved questions which must be addressed at this time in order to be sure that no long-range detrimental effects would result from a greatly expanded wood-fuel industry. The objectives of this project are: 1, To analyze the potential availability of surplus wood by region and compare that availability with potential regional demand for wood fuel. 2. To assess the current state of the technology for the procurement and utilization of surplus wood fuel, to project potential consumption of wood fuel on the basis of existing technology, and to identify any technology-related research and development needs. 3. To assess the environmental/ecological impacts with respect to SO2 emissions, and with respect to potential long-range impacts on our forests.
SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Industrial Environmental Research Lab.

2.0209,
TECHNICAL ECONOMIC EVALUATION AND REVIEW OF CONTINUOUS PROCESS TO MAKE ETHANOL FUELS BY VACUUM FERMENTATION OF SUGAR (ABBREV)
D.M. Jenkins, Battelle Memorial Inst., Columbus Laboratories, *505 King Ave., Columbus, Ohio* 43201 (W-7405-ENG-92-001)
No summary has been provided to the Smithsonian Science Information Exchange.
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0210,
INVESTIGATION OF FEASIBILITY OF USING SUGAR CANE, SUGAR BEETS, AND SWEET SORGHUM AS A SOURCE OF FUELS AND FEEDSTOCKS
E.S. Lipinsky, Battelle Memorial Inst., Columbus Laboratories, *505 King Ave., Columbus, Ohio* 43201 (W-7405-ENG-92-077)
No summary has been provided to the Smithsonian Science Information Exchange.
SUPPORTED BY U.S. Dept. of Energy

2.0211,
PREPARATION OF CRITICAL REVIEW REPORT ON FUELS FROM SUGAR CANE, SWEET SORGHUM & SUGAR BEETS, FOR DISSEMINATION BY SPONSORING AGENCY (ABBREV)
R.A. Nathan, Battelle Memorial Inst., Columbus Laboratories, *505 King Ave., Columbus, Ohio* 43201 (W-7405-ENG-92-098)
No summary has been provided to the Smithsonian Science Information Exchange.
SUPPORTED BY U.S. Dept. of Energy

2.0212,
PROCESS EVALUATION - MULTI-WASTE CO-FIRING IN UTILITY BOILERS
G.R. Smithson, Battelle Memorial Inst., *505 King Ave., Columbus, Ohio* 43201 (B624B-T24)
This task calls for a preliminary, 'paper study' type assessment of the potential for the use of a variety of waste materials in conjunction with municipal solid waste 9MSW) as combustion fuels for utility boilers. Waste materials to be investigated shall include municipal sewage sludges, industrial sludges, waste oils and lubricants, industrial wastes, commercial wastes, institutional wastes, and wood wastes. The study will focus on the technical feasibility of cofiring the various wastes with coal, oil, MSW, and other listed wastes. The study will also generally address the economic feasibility of cofiring the various wastes and will include a discussion of the logistical problems that presently can be identified.
SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Industrial Environmental Research Lab.

2.0213,
NATURAL WASTES TO CHEMICALS
A. Gerber, Horizons Research Inc., *23800 Mercantile Rd., Cleveland, Ohio* 44122
A determination of the feasibility of economic production of chemicals from natural and synthetic waste materials is being made. Raw materials such as diseased and dead trees and automotive trash are being considered. The proposed exploratory program for identification and definition of the products and yield of such products which can be formed from wood trash by subjecting the comminuted trash to the action of a combination of non-specific heterogeneous and homogeneous catalysts at an elevated temperature, in which reaction the heterogeneous catalyst is gradually transformed in situ to the homogeneous state. A host of organic chemicals are capable of being produced by the envisaged technique including hydrocarbons, olefins, aromatics, and a host of functionally oxygenated derivatives.
SUPPORTED BY Horizons Research Inc.

2.0214,
UPGRADING OF LOW GRADE FUELS THROUGH PRETREATMENT PROCESSES
T.E. Ban, McDowell Wellman Engineering Co., Dwight Lloyd Res Labs, *113 St. Clair Ave. N.E., Cleveland, Ohio* 44114
DESCRIPTION: Applied research studies as bench scale and pilot plant projects are carried out to develop more economical processes for utilizing low grade fuels. The processes include new and developed techniques of drying, carbonizing, pelletizing, agglomerating and gasifying applied to the low grade fuels such as coal, lignite, peat, wood, animal waste and municipal waste. The research leads to design and construction of commercial facilities which can more efficiently utilize the resources of the United States.
SUPPORTED BY McDowell Wellman Engineering Co.

2.0215,
RETORTING OF OIL SHALE AND OTHER LOW GRADE FUEL RESOURCES FOR RECOVERY OF OIL
T.E. Ban, McDowell Wellman Engineering Co., Dwight Lloyd Res Labs, *113 St. Clair Ave. N.E., Cleveland, Ohio* 44114
DESCRIPTION: Applied research studies as bench scale and pilot plant projects are carried out to develop more economical processes for extracting oil and fuel from oil shale and low grade fuel resources such as wood, peat, municipal refuse, animal waste, low grade coal, etc. The research leads to design and construction of commercial facilities which can more efficiently utilize the resources of the United States.
SUPPORTED BY McDowell Wellman Engineering Co.

2.0216,
TECHNIQUES FOR DISPOSAL OF VEGETABLE PROCESSING PLANT WASTES
J.R. Geisman, Ohio Agricultural Research & Development Center, *Wooster, Ohio* 44691 (OHO00425)
OBJECTIVE: Evaluate use and reuse of spent brine in pickle marking, reduce water use in processing both pickles and tomatoes, and develop techniques for reducing or utilizing solid wastes from food processing plants.
APPROACH: Studies will be done in commercial processing plants and the laboratory. Spent brine will be variously recovered in a semi operational basis and used to determine potential of such brine in quality pickle making. Emphasis will be placed on reducing water use in freshening of salt stock pickles, in recovering salt from freshing water and on separation, containment and reduction of water usage in tomato washing. Efforts will be made to process solid wastes so as to recover and utilize protein and lipid fractions or to allow its incineration as an energy source.
PROGRESS: Spent pickling brines we re recycled by pH adjustment for the fifth and sixth year to determine the limitation of the process. Fresh cucumbers were placed in these brines to ascertain any adverse effects on quality due to brine recycling. It appears that brines can be recycled for at least five years with a significant reduction in bloated (hollow) pickles. Lots were cured under low salt concentration to determine minimum quantities of salt which could be used for curing and overwintering the tanks without freezing. The high oil content (30%) of tomato seeds interferred with comminution. Hexane was used to produce an oil free extract. Determinations of quanitative and qualitative aspects of the protein extracted in this manner are being conducted. Samples of solid tomato cannery waste are being utilized for the production of single cell protein. This conversion could provide useful by-product for many tomato processors. On cabbage, field experiments were carried out using ethephon. The time of application and concentration were important in decolorizing the outer leaves without complete desiccation. One hundred ppm of ethephon applied to the cabbage was the proper concentration for field use. However, tem-

peratures below 50 F inhibit ethylene gas production. Therefore for field treatment of fall crops, it was found to not be practicable.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Ohio

2.0217,
ANIMAL WASTE MANAGEMENT CONFERENCE AND WORKSHOP
R.K. White, Ohio Agricultural Research & Development Center, Dept. of Agricultural Engineering, *Wooster, Ohio* 44691 (L770D-2-18)
A Livestock Waste Management Seminar and Needs Assessment Workshop will be held during the week of May 22, 1978 in Columbus, Ohio. Three new publications will be presented and reviewed in depth at the seminar. They are: (1) Environmental Impact Resulting from Unconfined Animal Production, (2) Evaluation and Economic Analysis of Livestock Waste Management Systems (Non-NPDES) and (3) Animal Waste Utilization on Crop and Pasture Land.
The needs workshop will assess current status and future research needs and the priorities for six areas of livestock production and waste management. The needs areas will include the topics of the three new publications (above) and (4) Resource Recovery from animal wastes (feed, fuel, etc.), (5) Odor--Cause and Abatement and (6) Conservation of Energy and Nutrients in existing and new management systems.
Needs assessment task groups (6 or 7 persons each) will prepare working papers for use at the Seminar and Workshop. A publication of the six needs assessments will be prepared.
Project has been awarded, seminar and workshop held as scheduled. Rough draft of assessment has been prepared as of July 1978.
SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Robert S. Kerr Environmental Research Lab.

2.0218,
ANIMAL WASTE MANAGEMENT WITH POLLUTION CONTROL
M.D. Paine, Oklahoma State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *107 Whitehurst Hall, Stillwater, Oklahoma* 74075 (OKL01484)
OBJECTIVE: Further develop animal waste management systems in the area of: Collection, transport, and management of wastes, treatment, and conditioning of wastes, and Economic, biological, and physical analysis and integration of above systems.
APPROACH: Determine the physical, thermal, and rheological properties of solid and slurry beef animal wastes. Analyze alternative beef feedlot layouts and waste handling systems determine minimum cost systems. Determine effectiveness of oxidation ditch treatment of beef animal wastes. Determine the costs and returns of current and proposed methods of handling animal wastes from selected confined animal feeding operations by using budgeting, linear programming, and other benefit-cost analysis techniques.
PROGRESS: One graduate student is studying anaerobic digestion of swine manure from holding pits. Present research is to determine daily loading rate to produce maximum methane production. During start-up runs, high nitrogen content of combined feces and urine has resulted in nitrogen poisoning of anaerobic seed stock obtained from municipal sources. The beef manure handling system for a slotted floor beef confinement building is installed. The rotating conical screen separator developed in this project received Wonder of Engineering Award from the Oklahoma Society of Professional Engineers.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Oklahoma

2.0219,
RENEWABLE SOURCES OF CELLULOSE
W.L. Hughes, Oklahoma State University, School of Engineering, Dept. of Electrical Engin, *Engineering N., Stillwater, Oklahoma* 74074
Much of the initial time was spent screening literature to identify plant species that exhibit potential for high yields of biomass to be used in conversion to liquid fuels. Three grasses and one woody species have been selected for an intensive investigation of energy content. Harvestable yields range from 4 to 6.5 metric tons per hector with varieties currently available.
SUPPORTED BY Oklahoma State Government

2.0220,
COMPETITION FOR RURAL RESOURCES
G. Sloggett, Oklahoma State University, U.S. Dept. of Agriculture Natural Resource Economics Div., *Whitehurst Hall, Stillwater, Oklahoma* 74074 (NRE-43-322-40-01)
OBJECTIVE: Develop functional relationships for the supply of land to agriculture and among competing uses, relating land availability to commodity prices, commodity policies, resource policies, non-agricultural competing uses and other significant variables. Relate agricultural land availability to agricultural capacity and develop linkages between policy variables and the amount of land used and agricultural capacity.
APPROACH: Develop a system to account for land use changes over time as between agricultural uses, abandonment, reclamation, by irrigation or drainage, recreation, forestry, urbanization and surface mining. Use economic theory, models and statistical techniques to estimate functions relating land use for various purposes to explanatory variables. Using a regional definition system consistent with other projects and progress areas of the Division and of the Commodity Economic Division, estimate land supply among competing uses by region. In cooperation with other Divisions, integrate land supply estimates with estimates of input supplies, yield projections and other measures of productivity to the capacity of agriculture.
PROGRESS: The year provided evaluations of the nature and extent of competition for rural resources from several sources. The actual withdrawal of land and water from agricultural production for surface mining will have rather minor consequences to agricultural output potentials. Preliminary analyses reveal the biomass energy could be competitive with returns from non- irrigated agricultural production at a cost of about $3 per 10 BTU's. Without significantly increased costs of alternative energy sources, land and water use for biomass production are not economic at the present. Should biomass production become feasible, sizable amounts of agriculture across the U.S. has revealed that each one precent increase in population density in urban areas is associated with a 1.05% increase in farmland values. Examination of the factors associated with groundwater irrigation development in the Central and southern Plains have not reached any conclusions. The effects of energy prices and availabilities on these agricultural production systems are significant, however. In studies of land conversion potentials in the southeast, it is revealed that topography, soil type, and fertility are important physical characteristics affecting land use.
SUPPORTED BY U.S. Dept. of Agriculture, Economics Statistics & Cooperatives Service, Natural Resource Economics Div.

2.0221,
CHARACTERIZATION OF METHANOL AS AN AUTOMOTIVE FUEL
Unknown, U.S. Dept. of Energy, Bartlesville Energy Research Center, *P.O. Box 1398, Bartlesville, Oklahoma* 74003
This contract includes the characterization of alcohol/gasoline blends which includes performance testing of alcohol/gasoline blends and straight methanol in spark-ignition internal combustion engines.
SUPPORTED BY U.S. Dept. of Energy, Div. of Transportation Energy Conservation

2.0222,
BARK UTILIZATION STUDIES
R.E. Curner, Oregon State Higher Education System, Oregon State University, Agricultural Experiment Station, Dept. of Forest Products, *126 Agriculture Hall, Corvallis, Oregon* 97331 (ORE-F-00940)
OBJECTIVE: To further the economic use of bark residues generated by the forest products industry in the State of Oregon. Determine volumes of bark currently produced in Oregon for decorative and mulch purposes, and use data for more efficient utilization. Increase the use of bark for horticultural and agricultural purposes through interdepartmental research. Engage in activities extending knowledge of bark and its properties to potential users.
APPROACH: There will be three subprojects under this study corresponding to the three objectives listed above. Subproject 1 is a data compiling and publishing effort based on a survey of Oregon bark producers. Subproject 2 will consist of greenhouse studies and limited field testing of plants grown in a 100 percent bark medium, with the work to be carried out by the OSU Horticulture Department. The Forest Research Laboratory will provide experimental bark and prepare it for use, and then use the resulting data to assist in establishing standard specifications for nursery and green house bark. Subproject 3 primarily is an extension-type effort to disseminate knowledge of bark and to prepare sample material for commercial trials.
PROGRESS: Several small subprojects were conducted with industry. Preparation of plastic molding extenders from bark of Douglas fir. Preparation of a plywood adhesive extender from Douglas fir bark. A successful mix was made by a synthetic resin producer. Attempted to prepare fuel bricks from bark using standard clay brick manufacturing facilities. The attempt was not successful. Prepared samples of pelletized bark residues for alternate boiler fuel. Species was ponderosa pine and the trial was successful. Worked with local landscaping firms and OSU Soils and Extension Departments on use of bark for decorative and mulch purposes.
SUPPORTED BY Oregon State Government

2.0223,
ANIMAL WASTE MANAGEMENT SYSTEMS FOR THE 1980'S
J.R. Miner, Oregon State Higher Education System, Oregon State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *126 Agriculture Hall, Corvallis, Oregon* 97331 (ORE00116)
OBJECTIVE: Conceptualize, develop, analyze & optimize animal manure mgmt systems with least cost & energy requirements for pollution control compatible with changing socio-politico-economic patterns. Develop optimal animal manure mgmt systems; characterize atmospheric contaminants & develop abatement methods; investigate use of manure mgmt systems by-products for energy sources, feed ingredients, plant nutrients; characterize the non-point pollution sources.
APPROACH: An integrated hydraulic swine manure transport & mgmt scheme will be developed, which involves separation of solids from a swine manure slurry, anaerobic digestion of the solids, growth of algae on the liquid fraction & re-use of the water for manure transport. Algae will be the livestock feed ingredient. Computer simulation models will be used to develop design procedures for control of runoff from cattle feedlots. The production, evolution & transport of gaseous by-products of manure decomposition will be studied.
PROGRESS: Testing of the rotating flighted cylinder as a biological waste treatment device was concluded. The concept was judged suitable for commercial development. The swine manure nutrient recovery system which simulates the use of waste heat was operated throughout the year. Methane was produced in the anaerobic digester at predicted rates. Biomass yields in the algae growth basins ranged from 10 to 130 g/m -day depending upon influent nutrient concentration, retention time in the basin, and operating temperature. A nitrogen balance on the system indicated 30 to 35 percent of the ammonia nitrogen in the influent was incorporated into the biomass regardless of the production rate. Manure covered surfaces associated with livestock production were evaluated on the basis of ammonia release rates and the impact on the surrounding atmosphere measured using the ammonia absorption rate concept. A definite increase in the ammonia absorption rate was measured in the vicinity of a swine confinement facility. A cattle feedlot runoff control simulation model was developed which integrates the effects of alternate dewatering policies on minimum facility volumes. The simulation model determined relationships between historical climatological data, dewatering schedules, and minimum feedlot runoff control volumes.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Oregon

2.0224,
HARVESTING SMALL LOGS AND RESIDUE WITH SKYLINES
D.E. Aulerich, Oregon State Higher Education System, Oregon State University, School of Forestry, McIntire Stennis Program, *126 Agricultural Hall, Corvallis, Oregon* 97331 (ORE-F-00053)
OBJECTIVE: Test prebunching as a means of increasing the efficiency of thinning. Test downhill yarding over intermediate supports. Determine costs of yarding residue with large and small yarders. Compare costs of hauling chipped and unchipped resi-

due. Determine falling, bucking and yarding of hardwoods for energy production.
APPROACH: Conduct production analyses of harvesting systems during operations. Develop relationships to predict costs and production. Develop a simulation to estimate costs and benefits of harvesting and handling forest residues for energy production.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Oregon

2.0225,
ENERGY UTILIZATION OF LODGEPOLE PINE RESIDUES
R.E. Currier, Oregon State Higher Education System, Oregon State University, School of Forestry, Dept. of Forest Products, *126 Agricultural Hall, Corvallis, Oregon* 97331 (ORE-F-00044)
OBJECTIVE: Prepare a working plan document under funding by the U.S. Department of Energy, for use by the Department and the U.S. Forest Service to identify methods of utilizing dead timber and forest residues as an alternate energy source in the study area.
APPROACH: Determine the type, volume and location of the raw material; analyze feasible methods of harvesting, handling and transporting the raw material; specify potential methods for utilizing the raw material to produce energy; analyze economic, social, and political consequences of alternate systems for utilizing the material.
PROGRESS: This project is just getting underway. Material is being collected for a bibliography on the subject.
SUPPORTED BY Oregon State Government

2.0226,
PRODUCTION PHYSIOLOGY OF LARGE TREES IN YOUNG-GROWTH FORESTS
W.L. Webb, Oregon State Higher Education System, Oregon State University, School of Forestry, Dept. of Forest Science, *126 Agricultural Hall, Corvallis, Oregon* 97331 (ORE-F-065)
OBJECTIVE: Examine physiological processes in young conifers which are related to primary production. Included are processes such as photosynthate conversion to biomass, the role of reserve carbohydrates and nitrogen, and radiant energy distributioin in the crown.
APPROACH: The approaches to be used include field experiments to measure short-wave radiation in tree crowns, use of N to follow nitrogen dynamics, carbohydrate dynamics and its relation to photosynthesis, and CO(2) pulse labelling to estimate photosynthesis. Experiments in controlled environment facilities are planned with C, and N on large conifers.
SUPPORTED BY Oregon State Government

2.0227,
FOREST RESIDUES REDUCTION PROGRAM CORE UNIT
E.H. Clarke, U.S. Dept. of Agriculture, Forest Service, Pacific Northwest Forest & Range Experiment Station, *P.O. Box 3141, Portland, Oregon* 97208 (PNW-2107)
OBJECTIVE: Carry out the planning and provide for execution of plans for a major RD&A Program effort concerned with solution of the problems: Lack of adequate procedures for residues management alternatives evaluation; marketing and other economic restraints cause potentially usable wood fiber to be unused; access to pertinent knowledge is limited; beneficial and detrimental effects or residues and residues treatment need quantification; applications of treatment techniques are lacking due to absences of guidelines, cost data, operational equipment and demonstrated benefits.
APPROACH: Independently and working through others, apply operations research to development of decision systems; examine existing and new timber marketing methods, product outlets and use of wood for energy conversion; devise and maintain an operational information retrieval method for pertinent fields; collect and interpret available and new knowledge on effects; pilot test and evaluate promising treatment technologies.
PROGRESS: This Research, Development and Application Program is continuing efforts to provide the land manager with tools, techniques, and methods necessary to integrate residues requirements into forest land management planning. Management techniques and sales arrangements are being developed to aid land managers in establishing desired residue levels and then to aid in attaining such levels through choice of the optimum residue treatment. Forest residue management guidelines were completed for both public and private forest lands in Pacific Northwest. Training sessions on application is in progress to help meet management objectives with best available technology.
SUPPORTED BY U.S. Dept. of Agriculture, Forest Service, Pacific Northwest Forest & Range Experiment Station

2.0228,
HANDLING AND UTILIZING ANIMAL WASTES IN THE SOIL-PLANT SYSTEMS
H.D. Bartlett, Pennsylvania State University, University Park Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *201 Shields Bldg., University Park, Pennsylvania* 16802 (PEN02255)
OBJECTIVE: Determine the effects of treatment and storage methods on wastes with respect to conserving and utilizing plant nutrients; determine the value of untreated and treated waste as a plant nutrient resource for agricultural crops through surface and subsurface application of wastes to the soil-plant system; determine the effects of methods and rates of waste application on crop production and crop quality.
APPROACH: Dairy manure will be subjected to various types of storage and the effects of storage determined by analysis of the waste before and after storage; effects on quality of water will be determined by analysis of soil and soil water. Fertilizer value will be based on yield and analysis of crops grown after application of the waste.
PROGRESS: Two rates of processed dairy manure (the effluent from biogas generator) were applied by subsurface injection methods in mid-April, approximately 10 days before planting, to no-till corn plots in one field each of an established sod (bluegrass), oat stubble and corn stubble. Manure placement was done to allow planting the corn directly in the manure injection rows, between injector rows, and with manure on one side only of the row, to provide manure nitrogen levels of 270 and 135 Kg N/ha. In addition, starter fertilizer (90 Kg of 10-20-10) was applied during planting to all plots. Crop samples were taken in September, with grain in full dent stage, for yield and plant analyses. Total dry matter (stalks and grain) yields were substantially higher for the 270 Kg/ha manure treatment than for the 135 Kg/ha treatments, which were not substantially different from the check rows that had the starter fertilizer. Also, studies were continued on the residual effects of 336, 448, and 560 Kg/ha of liquid manure injected two successive years, in Fall 1973 and 74 and Spring 1974 and 75, to orchardgrass sod. Yield data for 3 cuttings in 1977 showed a significant response to manure treatment levels and the response from spring applications was significantly greater than that for fall applications.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Pennsylvania

2.0229,
BIOGAS PRODUCTION FROM ANAEROBIC DIGESTION OF ANIMAL MANURE
H.D. Bartlett, Pennsylvania State University, University Park Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *201 Shields Bldg., University Park, Pennsylvania* 16802 (PEN02345)
OBJECTIVE: Determine the effects of operational and environmental factors on methane production by anaerobic digestion of animal residue at raised temperatures.
APPROACH: The 100 m anaerobic digester developed for studies on methane generation from dairy manure will be operated to determine the effects of the following on biogas production rate and quality. Recycle liquid separate from digester effluent as dilution water. Use of milking center wastewater for dilution water. Pretreat poultry manure to reduce ammonia concentration. Develop automatic controls for reduced labor. Conduct tests of biogas as combustion engine fuel.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Pennsylvania

2.0230,
METHANE GAS PRODUCTION FROM FARM WASTE
S.P. Persson, Pennsylvania State University, University Park Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *201 Shields Bldg., University Park, Pennsylvania* 16802 (PEN02132)
OBJECTIVE: Determine the technical requirements and economic feasibility for methane production from farm waste.
APPROACH: Compile basic information on methane production from organic material. Design pilot plant for producing methane from farm waste, build and test the system.
PROGRESS: The digester was in full operation from late 1975, accepting 6 m of diluted manure slurry per day from the 50 cow dairy herd. During this early period, the temperature of the digester was maintained at 27 C until late in January to complete operational start-up procedures and shake-down evaluation studies. Biogas was produced in increasing quantities during this early period but not sufficient to cover the heating needs of the digester. Propane had to be used as an alternate fuel. Experience was gained on boiler modification to utilize the dual fuel sources. By raising the digester temperature to 35 C, sufficient amounts of biogas were produced for heating the digester and some gas was permitted to escape to the atmosphere. The digester was maintained in full operation until May. The unit was shut down when the cattle were turned out to pasture. Following shut-down, the facility was disassembled for examination following the first season of operation. The systems and components were evaluated for wear, malfunction tendencies and possible corrosion problems. Following necessary modifications, the facility was reassembled for a second year of operation. Several changes and modifications in design of components, manure handling system, and present mechanical systems were included. The digester was restarted in late 1976.
SUPPORTED BY Pennsylvania State Government

2.0231,
METHANE GAS PRODUCTION FROM FARM WASTE
S.P. Persson, Pennsylvania State University, University Park Campus, School of Agriculture, Dept. of Agricultural Engineering, *201 Ag. Admin. Bldg., University Park, Pennsylvania* 16802
DESCRIPTION: A two-stage 4000 cubic feet anaerobic digester has been built for methane production from manure from a 50-cow dairy herd and other farm by-products. The purpose is to find which structural and methanical components are best suited with regard to cost, ease of operation and safety. The process is designed for high capacity and good control of environmental factors. Testing of systems for slurry handling, heat control and agitation is underway. Laboratory tests have been completed, establishing the best way of starting the process.
ADDENDA: Estimated calendar year funding reported as 1975 $32,000. This project is also supported by: Pennsylvania State University.
SUPPORTED BY Pennsylvania State Government

2.0232,
FOREST BIOMASS AS A SOURCE OF ENERGY AND BYPRODUCTS
W.K. Murphey, Pennsylvania State University, University Park Campus, School of Forest Resources, Mcintire Stennis Program, *102 Ferguson Bldg., University Park, Pennsylvania* 16802 (PEN02173)
OBJECTIVE: Determine the feasibility of using forest biomass as fuel for generating delectrcity for small-sized communities (10,000) or manufacturing firms in Pennsylvania, and the by-products from alternative processes.
APPROACH: This study will extensively evaluate the literature to assess the known technology of utilizing biomass directly or indirectly as a fuel source. In evaluating the alternative methods for using wood as a fuel source, value of the by-products will be considered. This study, in general, will examine existing sources of wood in Pennsylvania necessary to keep one 100 MW power plant going indefinitely. As a spin-off the literature will be examined to determine the problems associated with utilizing the forest biomass directly or as the raw material for products to be used as the fuel source for an electric generating plant.
PROGRESS: Wood resources of a 15-county region in northcentral Pennsylvania were evaluated to de-

termine the potential of these forests, in concert with the existing demands, to supply wood as an energy base. Using existing data, it was concluded that: 56 million cu. ft. of sound merchantable wood was left as logging residues from annual harvests; 125 million cu. ft. of sound merchantable wood could be annually removed in thinning-improvement cuttings; and 193 million cu. ft. of merchantable wood, bark, and branches if the annual cut was increased to harvest 50% of the current growth-in-excess-of-cut-balance. If used to fire an electric generating plant, maximum energy potential of 193 million cu. ft. of biomass would be 700 MW. A plant of this size could serve the electric needs of 68% of the population in the study area. Potential of this resource to supply heat energy and by-products is being examined to determine whether alternate processes would be a more optimum use. Present studies are focusing on the economics of supply in dollar and net energy values. Comparisons are also being made on differing cultural strategies from caretaker to intensive short rotations.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Pennsylvania

2.0233,

UTILIZATION OF WOOD WASTE PARTICLES

W.K. Murphey, Pennsylvania State University, University Park Campus, School of Forest Resources, Mcintire Stennis Program, *102 Ferguson Bldg., University Park, Pennsylvania* 16802

Description: Wood as an energy source is being explored. Initially, the relationship between moisture content (oven dry basis) and gross heat of combustion measured by a calorimeter was determined for hardwoods, bark and waste papers. Presently work is projected to examine feasibility of communities established with wood as sole energy source. Processing variables are being examined.

Addenda: Estimated calendar year funding reported as 1974 $11,000, 1975 $11,000.

SUPPORTED BY Pennsylvania State Government

2.0234,

FOREST AS A SOURCE OF ENERGY FOR A PENNSYLVANIA TOWN OF 10,000 - A FEASIBILITY STUDY

W.K. Murphy, Pennsylvania State University, University Park Campus, School of Forest Resources, *102 Ferguson Bldg., University Park, Pennsylvania* 16802

The objective of this research is to determine the feasibility of using forest biomass as fuel for generating electricity for small-sized communities and manufacturing firms in Pennsylvania.

Since our sources of oil, natural gas and coal are becoming increasingly more difficult to obtain, the law of diminishing returns may become an important factor. Another way of approaching this is not to look at gross energy but net energy from a resource. Net energy is what is obtained from the resource at conversion site minus the energy expended to produce, procure, process and transport the resource to the conversion site. This concept becomes increasingly important as we expend larger amounts of energy to drill deeper for less concentrated oil and natural gas supplies. Wood biomass as a solar converter may begin to compare very favorable on a net energy basis in the future.

SUPPORTED BY Pennsylvania State Government

2.0235,

RESOURCES EVALUATION

C.E. Mayer, U.S. Dept. of Agriculture, Forest Service, Northeastern Forest Experiment Station, *6816 Market St., Upper Darby, Pennsylvania* 19082 (NE-4101)

OBJECTIVE: Inventory and assess the renewable resources of the fourteen Northeastern states in accordance with the objectives of Section 9 of the McSweeney-McNary Act of 1928 and the Renewable Resources Planning Act of 1974 (PL 93-378).

APPROACH: The Resources Evaluation Work Unit is the only organization that conducts extensive resource inventories and provides comprehensive resource information on a continuing basis. Such a multifaceted forest resources evaluation program requires massive amounts of data which can be provided only through a comprehensive inventory and assessment of the renewable resources on forest land by state resurveys. State resurveys are a step in the preparation of regional information for the 1979 and future national assessments. The evaluation of timber removals is an important part of the total forest resources evaluation picture and a necessary supplement to the basic inventory data. There is a need to devote considerable effort to resource inventory techniques research in order to develop and maintain efficient sampling and other data acquisition and processing procedures to inventories of timber and other renewable resources. Cooperative efforts and support of state and federal agencies and others is essential to an overall efficient operation.

PROGRESS: Wood industries in New England have an opportunity to convert residues to a dependable fuel supply. In 1973 harvesting and land clearing generated 8.5 million tons of unused wood residues. This material has a net energy value of 80 trillion BTU's. NE-46 shows that net annual growth in Vermont is only 24 cubic feet per acre per year. Valuable growing space is occupied by inferior trees. One tree in 3 is a cull. But 30% of the forest land is capable of growing more than 85 cubic feet per year. NE-50 shows that forest industries used more than 98 million cubic feet of Kentucky timber in 1974. Nearly 89% was sawlogs--unchanged from 1969. Pulpwood gained 69% over 1969. Veneer-log output fell 10% and cooperage log production dropped 43%. NE-51 shows that forest-land owners in Vermont and New Hampshire hold forest land for its amenity value. Despite this most don't have negative feelings toward timber harvesting or forest management. It would appear that expansion of management and timber production are good if the owner's primary objectives (Text Truncated - Exceeds Capacity)

SUPPORTED BY U.S. Dept. of Agriculture, Forest Service, Northeastern Forest Experiment Station

2.0236,

SOLID-FUEL COMBUSTION RESEARCH FACILITY

D. Bienstock, U.S. Dept. of Energy, Pittsburgh Energy Research Center, *4800 Forbes Ave., Pittsburgh, Pennsylvania* 15213

The objective of this project is to study the handling, pulverizing, combustion, and fouling characteristics of coal-derived fuels such as solvent-refined coal (SRC), chars from various coal gasification and liquefaction processes under development, and blends of coal and various fuels such as process char, char prepared from agriculture and lumber wastes, and petroleum coke. The effects of combustion parameters such as primary and secondary air temperature, excess air, and particle size of ignition, flame stability and combustion efficiency will be investigated. A further objective is the investigation of the removal of SO2 from the flue gas via minerals such as nahcolite, trona, etc., and a baghouse filter. Handling and combustion studies of the coal-derived fuels and chars from goal gasification and liquefaction processes will be continued in an existing 500 lb/hr pulverized-fuel-fired furnace designed to simulate the performance of a commercial steam generating boiler. In addition, handling, blending, pulverizing, and combustion studies will be conducted with blends of coal and coal process char, char produced from lumber and agricultural wastes, and petroleum coke. SO2 emission control techniques that are tailored for smaller industrial and utility boilers will be studied and evaluated.

BIBLIOGRAPHIC REFERENCES: Yeh, J.T., C.R. McCann, J.J. Demeter, and D. Bienstock, Removal of Toxic Trace Elements from Coal Combustion Gas, Report of Investigation, PERC/RI-76/5, September 1976. Demeter, J.J., C.R. McCann, J.M. Ekmann, and D. Bienstock, Combustion of Char from Pyrolyzed Wood Waste, PERC/RI-77/9, July 1977.

SUPPORTED BY U.S. Dept. of Energy, Office of Fossil Energy

2.0237,

THE BIOLOGICAL PRODUCTION OF ORGANIC SOLVENTS FROM CELLULOSIC WASTES

E.K. Pye, University of Pennsylvania, School of Engineering & Applied Sciences, *4001 Spruce, Philadelphia, Pennsylvania* 19104 (E(11-1)-4070)

A well-established fermentation process for producing acetone and butanol became uneconomic in the 1940's when these solvents could be made cheaply from ethylene. This project will investigate the economic potential of a multi-step fermentation process using modern biotechnology and deriving the key substrate, glucose, by hydrolysis of cellulosic materials. Cattle feedlot wastes have been selected initially as a source of cellulose because of availability and the pollution abatement credits that can be taken. Research and development will be conducted on pretreatment of cattle wastes to improve hydrolysis, cellulase production, enzymatic hydrolysis of cellulose, and anaerobic fermentation to produce solvents. The enzymes will be derived from Thermoactinomyces to obtain a high temperature, high efficiency digestion process. Mutants will be screened to find those producing the best yields and the most desirable mix of celluase activities. At least four enzymes participate in cellulose degradation, and these enzymes and their mechanism will be characterized. The solvent fermentation studies will emphasize continuous processing with conditions chosen to minimize diversion of substrate for cell maintenance. A continuing analysis of the entire system will focus research on the most cost-sensitive steps.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0238,

PRODUCTION OF ALCOHOL FUELS FROM CELLULOSE DERIVED FROM AGRICULTURAL WASTES AND CROP BIOMASS

E.K. Pye, University of Pennsylvania, School of Medicine, Dept. of Biochemistry & Biophysics, *36th & Hamilton Walk, Philadelphia, Pennsylvania* 19104 (EY-76-S-02-4070)

The purpose of this project is to investigate the technical and economic constraints on a modular process for the conversion of cellulosic biomass, such as feed-lot and agricultural residues, as well as farmed energy crops, into liquid fuels and other oil-sparing chemicals (ethanol, butanol, acetone, acetate, etc). The process includes (a) an alkaline pretreatment of the cellulosic residue, (b) optimal production of a high-temperature cellulase from Thermoactinomycyes, (c) maximum saccharification of the pretreated residue to fermentable sugars, and (d) optimal ethanol production from Cl. thermocellum and butanol production from Cl. acetobutylicum. The latest results indicate an advantage for a simpler, combined high temperature saccharification and fermentation step, coupled with vaccum recovery of ethanol and solvent extraction of butanol (for minimal cost and energy use.) This process is now being intensively investigated. Alcohol fuels from this process promise to be economically competitive with oil-based fuels early in the next decade if the generally projected oil price increases occur. This project has a subcontract.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0239,

WOOD AS AN ENERGY SOURCE IN THE RURAL-URBAN COMPLEX

W. Could, University of Rhode Island, Agricultural Experiment Station, Mcintire Stennis Program, *Administration Bldg., Kingston, Rhode Island* 02881 (RI00960)

OBJECTIVE: Determine the potential demand for fuelwood in the southern New England rural-urban complex. Evaluate the productivity of typical sites for growing fuelwood. Assess ways to more efficiently use the resource by determining practical methods of seasoning wood.

APPROACH: Several even-aged stand sites will be selected to include well-drained, moderately well-drained and poorly drained locations. Cordwood biomass productivity of each stand will be determined by sample plots. Individual trees will be randomly selected by diameter-class for distructive sampling. Root systems of several sample trees will be examined for sprout vigor and tree origin. Fertilization to increase growth rates will be evaluted. Trends in fuelwood consumption will be determined. Various aspects of wood seasoning will be investigated.

PROGRESS: Techniques for biomass sampling have been formulated and plots will be established when snow cover disappears. Plans for harvesting of wood for seasoning experiment are complete as is design of questionnaire to sample wood fuel use by public.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Rhode Island

2.0240,

A STUDY OF THE CONVERSION OF AGRICULTURAL WASTES TO LIQUID FUELS

G.T. Felbeck, University of Rhode Island, Agricultural Experiment Station, Dept. of Food Science & Technology, *Administration Bldg., Kingston, Rhode Island* 02881 (RI00019)

OBJECTIVE: Determine by means of simulation experiments the naturally occurring conditions under which various organic materials could be converted to hydrocarbons. Apply the results of these experiments to the problem of geochemical prospecting for oil with particular emphasis on increasing the efficiency of drilling productive wells. Apply the processes developed to the conversion of agricultural waste materials to liquid fuels.

APPROACH: A matrix of organic and inorganic materials, blended to simulate marine sediment mixtures will be subjected to appropriate laboratory conditions to simulate reaction times of up to 10 years at 100 C. Reaction products will be compared with crude oil hydrocarbons to test process validity. The catalytic action of various metal compounds will be evaluated.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Rhode Island

2.0241,

ANIMAL WASTE TREATMENT AND RECYCLING SYSTEMS

R.O. Hegg, Clemson University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Long Hall, Clemson, South Carolina* 29631 (SC00049)

OBJECTIVE: Identify and monitor residual components that may present nuisances and hazards to human and animal health and to the environment, and to study methods of controlling these. Study performance of various treatment systems on animal wastes and wastewater prior to disposal by use of coordinated laboratory, pilot scale and field research.

APPROACH: Odorous gaseous components produced from the anaerobic treatment of poultry manure will be identified. Ozone will be tested for its effect on the odorants and on the intensity of the odor of the gases produced. High-rate anaerobic lagoons (relative to present practice) will be employed in a laboratory study to test the influence of loading rate, temperature and detention time on poultry waste degradation, odor production sludge accumulation and effluent characteristics.

PROGRESS: Work has continued on the use of a 1000 gallon (3780 liter) insulated, pilot scale anaerobic digester to generate methane. The feed material has been swine waste at rates from 0.20 to 3.0 gm VS/1/day. This has been at less than the desired feed rates, due to problems in having enough animals available. A hot water tank with a circulating pump was provided to help keep the digester liquid above 25 C during cold weather periods. Volatile solids reduction has been in the range of 50 to 70% with solids detention of 20 days. Daily gas production rates have ranged from nearly zero at times to as high as 0.5 1 of gas per liter of tank.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, South Carolina

2.0242,

RENOVATION OF SEWAGE EFFLUENT BY FORESTED SOIL AND SUBSEQUENT EFFECTS ON NUTRIENT REMOVAL BY TREE GROWTH

C.L. Lane, Clemson University, School of Forestry & Recreational Resources, Dept. of Forestry, *Long Hall, Clemson, South Carolina* 29631 (SCZ00785-FR)

OBJECTIVE: Determine the capacity of soils under forest vegetation to renovate sewage effluent. A second objective will be to determine the efficiency of nutrient removal by a loblolly pine (Pinus taeda L.) stand and a high density mixed hardwood coppice stand.

APPROACH: Effluent from the Town of Clemson's treatment plant will be spray irrigated on plots at a rate of 0, 2.5, and 5.0 cm per week with a variable rate to maintain approximately field capacity. Analysis of soils and effluent will be made for Cu, Zn, Ca, K, Total N, Na, C1, S, P, and pH. Soil physical properties will be determined before and after application. Nutrient uptake by vegetation and tree growth will be measured. Biomass production will be determined. Coliform bacteria will be monitored in the soil profile. Irrigation will continue for two years.

PROGRESS: Tree heights and diameters on all plots were measured prior to application and are being remeasured after the first growing season. All herbaceous vegetation has been identified and a line transect measured on each plot. Soil physical and chemical properties have been measured. Chemical properties of the sewage effluent and the adjacent stream are monitored. The irrigation system for the application of the sewage effluent has been installed. An additional irrigation system has been installed on the adjacent stream to determine the effects of water application only. After one growing season, there has been no nutrient buildup in the soil at any application rate (0,25 5 cm per week, and a variable rate). Frost damage was visible on the irrigated plots first because of the more succulent tissue. Some fecal coliforms are present at the 45 cm level in the soil.

SUPPORTED BY South Carolina State Government

2.0243,

FUEL PLANTATION RESEARCH

J. Stubbs, U.S. Dept. of Agriculture, Forest Service, *Aiken, South Carolina* 29801

Laboratory and field experiments will be employed to determine the best techniques for increasing oleoresin yield during the treatment and processing stages. Results will prove whether this technique is economically and technologically feasible as a means of increasing the yield of oleoresin from southeastern pine forecasts.

SUPPORTED BY U.S. Dept. of Energy, Div. of Biomedical & Environmental Research

2.0244,

A STUDY OF A COMPLETE DISPOSAL-RECYCLE SCHEME FOR AGRICULTURAL SOLID WASTES

R. Norman, State University & Community College System of Tennessee, Tennessee State University, School of Agriculture & Home Economics, Dept. of Animal Science, *Nashville, Tennessee* 37203 (TENX-PR-0002-34994)

OBJECTIVE: The anerobic conversion of manure to methane gas will be studied to determine if this process is adaptable to the needs of the small farmer. Can this process be used as a complete farm waste recycle scheme? Will the by-products of the process be beneficial to the farmer, i.e. can he make use of the methane and the sludge? Is the process economical? What level of the technical competence is required to construct, operate and maintain the unit?

APPROACH: A 'bio-gas' plant after the design of Singh will be designed and constructed by Tennessee State University. Various mixtures of animal manure and farm clippings will be batch fed to the units until gas production commences. Determine an optimum mix for decomposition and methane production the feed will be analyzed primarily for its fertilizer potential. Based on the design efforts, labor required for construction, feed composition, gas quality and quantity, sludge quality and quantity, length of time required for decomposition and gas production, and on the maintenance required, adaptability of the process to the needs of the small farmer will be determined.

PROGRESS: Unit I of the full-scale bio-gas plant was charged with 4765 liters of a mixture composed of water and manure (2.8 percent solids). After a fourteen day detention lime, seventy-five gallons of mixture were wasted and seventy-five gallons of fresh mix were added to the unit. The pH of the mixture was maintained above 6.5 by the addition of lime. The sludge temperature varied from 40 C to 44.4 C, being controlled by an internal copper coil heat exchanger. After a two-week detention time, the gas volume generation rate was 3.5 ft. 3/hr. and eventually increased to 5 ft. 3/hr. near the end of the testing period. Gas samples were analyzed in a gas chromatograph. Typically, the generated gas was 62 percent methane and 38 percent carbon dioxide. The influent and effluent BOD and COD were measured. As in the pilot plants, both these quantities were reduced upon digestion.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Tennessee

2.0245,

AN EVLUATION OF A COMPLETE DISPOSAL-RECYCLE SCHEME FOR AGRICULTURAL SOLID WASTES

M.R. Busby, State University & Community College System of Tennessee, Tennessee State University, School of Engineering & Technology, Dept. of Mech Engin, *Nashville, Tennessee* 37203 (TENX-PR-0002)

OBJECTIVE: Operate two digesters for a period of twenty-four months. Conduct analytical tests on raw influent, digested sludge, gas, and mixed liquor. Measure volume and composition of the gas produced. Measure volume of sludge produced. Analysis of the data will be made in order to determine the feasibility of a small farmer incorporating an anaerobic digester for recycling or replacing conventional resources, e.g. fertilizers or feed supplements.

APPROACH: Careful performance data will be collected and analyzed in our Environmental Laboratory. The influent, digested sludge, liquor, and effluent will be analyzed for pH, alkalinity, total solids, total volatile solids, bio-chemical oxygen demand, ammonia nitrogen, total nitrogen, and nitrates. The volume of gas generated will be monitored by wet test meters and the composition determined from a gas chromatograph for methane and carbon dioxide percentages. These analyses will characterize the raw waste and measure the effectiveness of the process.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Tennessee

2.0246,

BIOCONVERSION OF LIQUID AND SOLID WASTES TO FUELS AND PRODUCTS

W.L. Griffith, U.S. Dept. of Energy, Oak Ridge National Lab., *P.O. Box X, Oak Ridge Operations Office, Oak Ridge, Tennessee* 37830

Description: We are developing two processes, the ANFLOW process, and the ALIC process, which can be used to convert various waste materials to fuels or to industrial intermediates. The ANFLOW process is an anaerobic packed-bed biological reactor process in which wastes are treated as they are pumped up through the packed bed. The ALIC process is an aerobic lignicellulosic waste degrading process. These processes can, either singly or together, be used to treat large numbers of wastes from processes such as cheese-making, coal liquifaction, solid waste treatment uranium processing, and film production. Domestic sewage can also be treated using these processes. Valuable industrial products, such as lactic acid, ethanol, methane, hydrogen sulfide, and fatty acids can be made using these processes.

Addenda: Estimated calendar year funding reported as 1974 $20,000, 1975 $20,000.

SUPPORTED BY U.S. Dept. of Energy, Unspecified Unit

2.0247,

BENEFICIAL USES OF WASTE HEAT FOR AGRICULTURAL PURPOSES

I. Spiewak, U.S. Dept. of Energy, Oak Ridge National Lab., *P.O. Box X, Oak Ridge Operations Office, Oak Ridge, Tennessee* 37830 (W-7405-ENG-26)

DESCRIPTION: This is a long-range project with the objective of developing beneficial uses of waste heat contained in TVA nuclear plant discharge water for agricultural purposes. The waste heat could be utilized in 1) heating and cooling greenhouses for year-round horticultural production, 2) determining the influences of increasing soil temperature in open fields on plants, 3) irrigation and frost-control to lengthen the growing season, 4) controlling temperatures in confined livestock feeding facilities, and 5) recycling livestock wastes to purify water and produce protein for livestock feed. Initial work has emphasized objective one and two. A pilot waste heat greenhouse has been completed and initial engineering and horticultural tests are under way at the National Fertilizer Research Station, Muscle Shoals, Alabama. Soil heating investigations were conducted with several vegetable crops in 1972 and are presently being conducted with several field crops. Tests using soil heating plus temporary greenhouse-type coverings have been conducted with several horticultural crops. A prototype greenhouse for operation at Browns Ferry has been designed by the University of Arizona.

SUPPORTED BY U.S. Dept. of Energy, Div. of Reactor Standards

2.0248,

IMPROVEMENT AND DEMONSTRATION OF HARVESTING TECHNOLOGY AND METHODOLOGY

W.W. King, U.S. Tennessee Valley Authority, Div. of Forestry Fisheries & Wildlife Development, *Norris, Tennessee* 37828

To develop workable harvesting machinery support and business systems for efficient removal of wood for energy use. To increase the volume and value of our harvested timber crops thereby increasing the

stumpage return on landowner's investments. To improve the overall efficiency and cost effectiveness of the Valley's sawlog and pulpwood logging industry while concurrently protecting the land and water. To improve the present forest industry workers' lot. To train and certify new workers and timber harvesting managers for careers in timber harvesting.

Accomplishments were as follows: Published report on Factors Affecting The Production of Rubber Tired Skidders. Another study on Factors Affecting the Cost and Construction of Logging Roads was completed and the report is in press. Fieldwork is underway on two other studies: Factors Affecting the Cost of Felling, Limbing and Bucking Trees With Chainsaws and Factors Affecting Truck, Rail and Barge Cost of Round Wood. A study on sawlog salvage from low-grade tree-length chipwood will be completed and reported as a Masters Thesis.

SUPPORTED BY U.S. Tennessee Valley Authority

2.0249,

WOOD FOR ENERGY

E.L. Klein, U.S. Tennessee Valley Authority, Div. of Forestry Fisheries & Wildlife Development, *Norris, Tennessee* 37828

The objective is to explore the possibilities of using industrial and logging residues, cull and salvage timber, whole tree chips, and wood from land clearing for energy and fiber production.

Efforts have been, and will continue to be, directed toward determining the amounts of softwood and soft and hard hardwoods on a green and oven-dry basis for bark, chippable, shavings, and fines; and their county location in the 125 Tennssee Valley county area. Data was published for 1970, 1974, and 1975. Plans are to continue with 1978 or 1979 and 1980 data.

Other plans are to install a mobile pyrolysis unit at Maryville College, Maryville, Tennessee. This unit will provide wood gas for campus heat. Fuel savings and income from char sales will amount to $4 million in 10 years. Ninety wood burning residential stoves have been installed in electrically heated homes. Preliminary data show kilowatt-hour savings average 50 percent. Studies are underway at two colleges and one county school system on the economic feasibility of wood residue as a heat source. The wood marketing center for residential and industrial wood fuels is in the planning stage. The economics of harvesting whole trees for energy wood is being considered.

SUPPORTED BY U.S. Tennessee Valley Authority

2.0250,

METHANOL-FUEL EFFECTS ON SPARK IGNITION ENGINE LUBRICATION AND WEAR

E.C. Owens, Southwest Research Inst., Army Fuels Lubricants Res Lab, *8500 Culebra Rd., San Antonio, Texas* 78228

This project is to assess the impact of alcohol-containing motor fuels on conventional spark ignition engine lubrication and wear. A series of single-cylinder engine tests are being conducted to evaluate the nature and extent of any lubricant related problems. The work to date indicates that during periods of low-temperature engine operation, methanol and its combustion products, when reacted with the lubricant through blowby, increases the rate of wear of the piston rings and cylinder bore significantly during short-term testing. Evidence also indicates possible incompatibility with conventional lubricant additive packages resulting in diminished engine protection and precipitation of additive components. Plans for ongoing and future work leading to development of lubricants for use with alcohol-containing include extensive chemical analysis of engine blowby from the piston ring zone and evaluation of a series of commercial and experimental lubricant formulations.

SUPPORTED BY U.S. Dept. of Energy

2.0251,

TESTING RIVER BIRCH FOR SILAGE CELLULOSE PRODUCTION

R.R. Hicks, Stephen F. Austin State University, School of Forestry, Mcintire Stennis Program, *Nacogdoches, Texas* 75962 (TEXY00009)

OBJECTIVE: Investigate the feasbility of using river birch and sycamore for wood fiber production when planted at 2x2' spacing and harvested with a corn silage harvester.

APPROACH: Rooted cuttings from 10 clones each of river birch and sycamore will be planted on an alluvial site. Total fiber yield and wood properties will be measured after the third growing season.

PROGRESS: A plantation of river birch and American sycamore seedlings was established in January 1975 and first and second year growth and survival data were collected. The plantation contained 10 open-pollinated families of each species in a randomized complete-block design and 4 replications. Survival was excellent with both species almost 100%. River birch was significantly larger than sycamore for both height and diameter. The mean heights were 700 mm and 425 mm for river birch and sycamore, respectively and corresponding root collar diameters were 6.5 and 5.0 mm. Variance among families was significant for both species. After the second year, river birch seedlings averaged 287.20 cm tall and corresponding height for sycamore was 210.47 cm. Narrow sense heritability estimates for first year heights computed by sib analysis were greater than unity, in both species, possibly due to maternal or confounding nursery effects. Second-year estimates for river birch were 0.22, for sycamore, 0.77. Simple correlation coefficients between first- and second-year heights were 0.418 and 0.532 for river birch and sycamore respectively.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Texas

2.0252,

ENERGY UTILIZATION AND EFFICIENCY IN AGRICULTURE

W.A. Lepori, Texas A & M University, College Station Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *College Station, Texas* 77843 (TEX06123-RI)

OBJECTIVE: Identify present energy utilization and future needs for specific products of the Texas Agricultural Industry. Analyze methods to conserve the use of energy in present agricultural practices. Develop improved production and processing practices to reduce high energy consuming operations. Develop alternative sources of energy for agriculture.

APPROACH: Mass and Energy flow models will be developed for individual products using network theory or similar techniques. Various production scenarios will be hypothesized and tested with the models to determine potential energy conservation practices. Alternative practices will be developed and new research proposed where high energy consuming operations are found. Economic implications of the production scenarios will be investigated.

PROGRESS: Energy availability is a major factor enabling high agricultural productivity and rising fuel prices are beginning to economically limit energy use for some operations. Analysis of pumping water using presently available alternate power units reveals that in many cases fuel costs represent from 50 to 70 percent of the total fixed and variable power unit cost. With present fuel prices, the most attractive fuels are, electricity, diesel and natural gas. Natural gas is generally the 'cheapest' fuel to use presently but when natural gas prices reach $2.25 to $2.50 mcf, other fuel alternatives become attractive. A power unit pumping cost generator model has been developed to provide aid in selecting alternatives on an individual well basis. Estimates of the average, high, and low quantity of residue available after harvest was made for sorghum, cotton, corn, and wheat for the years 1970-74 in each Texas county. These crops represent almost 75 percent of the total crop acreage harvested in Texas during these years. Quantity of cotton gin trash accumulated at gins was also estimated for each county. Almost 17.5 million tons of residue are produced in Texas by these four major crops and have a heat value of .23 Quads (10 BTU). Ten counties containing cotton gin trash with an estimated 6.9 x 10 BTU of energy were used to analyze cost.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Texas

2.0253,

QUALITY FACTORS IN SORGHUM BREEDING LINES FOR LIVESTOCK, ENERGY AND INDUSTRIAL UTILIZATION

G.G. McBee, Texas A & M University, College Station Campus, Agricultural Experiment Station, Dept. of Soil & Crop Science, *College Station, Texas* 77843 (TEX06289)

OBJECTIVE: Determine genetic variability in major grain and forage sorghum breeding lines for cyanogenetic glucoside levels. Determine inherent variation in levels of certain carbohydrate fractions plus true and apparent digestibility of stover among selected grain and forage sorghum parental material. Evaluate stover for industrial and energy utilization.

APPROACH: Grow selected breeding lines under known population and fertility conditions. Flag leaf samples analyzed potentiometrically for p-HCN. Selected sections of plant analyzed for carbohydrates by hydrolysis and spectrophotometric technique and true and apparent digestibility by in vitro method. Energy and industrial determinations involve fermentation, mass spectrometry and calorimetric methods.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Texas

2.0254,

CHEMICALS AND ENERGY FROM FORESTRY AND RELATED RESIDUES

E.J. Soltes, Texas A & M University, College Station Campus, Agricultural Experiment Station, Mcintire Stennis Program, *College Station, Texas* 77843 (TEX06279)

OBJECTIVE: Identify and address technical and economic constraints in residue utilization. Identify and develop processes for producing chemical and energy products from residues. Evaluate various preprocessing schemes to enhance residue utility in product generation.

APPROACH: Assess and address biomass availabilities; harvesting and transportation problems. Evaluate pyrolysis as a means of generating clean, volatile fuels from dirty residues. Characterize products of pyrolysis of various residues. Identify and develop pyrolysis parameters and post-pyrolysis processing in maximizing yield of useful products and intermediates. Evaluate the effects of composting and other processes on residue utility.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Texas

2.0255,

SYSTEMS ANALYSIS OF COTTON GIN TRASH UTILIZATION ALTERNATIVES

C.B. Parnell, Texas A & M University, College Station Campus, School of Engineering, Dept. of Agricultural Engineering, *P.O. Box F E 44, College Station, Texas* 77843

The objective of this research is to develop a systems engineering model structured to permit the quantification of the energy, economic, and environmental costs associated with utilizing cotton gin trash. Alternatives to be studied include utilization as a cattle fed, as compost material, and as an energy source. The model will be used to determine the best alternative for gins processing picked and stripped cotton at rates of 10, 15, 20 and 30 bales per hour. Projects results are expected to be useful in developing conceptual designs of systems for the safe utilization of cotton gin trash at minimum cost with acceptable rates of return on equipment and process investments.

SUPPORTED BY U.S. National Science Foundation, Div. of Applied Research

2.0256,

APPLICATION OF SGFM TECHNOLOGY TO OTHER FEEDSTOCKS

W.J. Huffman, Texas Tech University, School of Engineering, Dept. of Chemical Engin, *P.O. Box 4340, Lubbock, Texas* 79409

A counter current pyrolysis reactor for cattle wastes has been invented which allows volatile organic compounds to escape from the heating zone very rapidly. This results in a different mix than has been observed in other pyrolysis research, particularly in unusually high concentrations of ethylene. Fuel values of gases plus the sparing of petroleum needs by ethylene appear favorable economically and in terms of their impact on U.S. energy needs.

This project will continue process development and investigate other feedstocks. Scale-up data will be generated, and more solid foundation will be laid in terms of reactor dynamics and pyrolysis chemistry. The main goal is an early assessment of the economic potential of this process.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0257,

ECONOMIC ANALYSIS OF ENGINEERING IMPROVEMENTS TO CONVENTIONAL OPEN PAN EVAPORATORS

F.M. Laing, University of Vermont & State Agricultural College, Agricultural Experiment Station, Dept. of Botany, *85 S. Prospect St., Burlington, Vermont* 05401 (VT00182)

OBJECTIVE: Conduct an economic analysis of engineering improvements to conventional open pan evaporators for production of maple syrup. Specifically collect economic data on evaporator efficiencies due to redesigns such as sap preheaters, new baffle design, burner redesign, etc.

APPROACH: Use two commercial evaporators, one as control, other to be modified. Measure all operating factors to establish economic efficiency of modifications against control.

PROGRESS: Evaluation of wood chips as an alternate fuel for maple evaporators indicate good fuel efficiency with a fuel cost reduction of about 50%. Tests of a sap preheater, using steam from the evaporator as a heat source, showed a consistent efficiency gain of 15 to 17% over conventional evaporators. Statistical analyses of the vapor compression distillation unit data are not complete but preliminary results show applicability for large scale operations. A system of profiling syrups for flavor levels and off-flavors has been initiated using gas chromatography. Work will be continued under Hatch project 264.

SUPPORTED BY Vermont State Government

2.0258,

MAPLE PROCESSING EQUIPMENT AND RELATED PROBLEMS

F.M. Laing, University of Vermont & State Agricultural College, Agricultural Experiment Station, Dept. of Botany, *85 S. Prospect St., Burlington, Vermont* 05401 (VT00264)

OBJECTIVE: Investigate modifications to conventional open-pan evaporators which will provide greater economic efficiencies. Investigate and evaluate other processing equipment which might be applicable to maple processing. Investigate quality control performance of units researched for comparison with conventional evaporator output.

APPROACH: Test of automatic feed wood chip fueled maple syrup evaporator. Engineering and cost efficiency of different wood fuel types and implications to equipment modification. Economic and engineering efficiencies of modified preheaters installed on conventional evaporator systems. Engineering and economic efficiency analyses of vapor compression distillation, redesigned for processing sugar solutions. Characterization of flavors and off-flavors with taste panels, chemical and physical analyses, as affected by variables associated with maple syrup products manufacture.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Vermont

2.0259,

WOOD RESIDUE FUELS FOR MAPLE EVAPORATORS AND OTHER HEATING USES

F.M. Laing, University of Vermont & State Agricultural College, Agricultural Experiment Station, Dept. of Botany, *85 S. Prospect St., Burlington, Vermont* 05401 (VT00198)

OBJECTIVE: Devise and demonstrate use of wood residues as alternative fuels for maple evaporators and other uses.

APPROACH: Modify existing evaporator and chip delivery system. Study procurement, handling, drying, storage, and combustion on wood residues. Construct energy balances. Advise and aid in construction of demonstration units at maple syrup production sites. Monitor performance and derive energy balances and costs.

SUPPORTED BY Vermont State Government

2.0260,

PRODUCTION OF BIOMASS FOR ENERGY ON ABANDONED FARMLANDS

F.M. Laing, University of Vermont & State Agricultural College, Agricultural Experiment Station, Dept. of Botany, *85 S. Prospect St., Burlington, Vermont* 05401 (VT00905)

OBJECTIVE: Evaluate hardwood trees and shrubs providing highest biomass potential on short cutting cycles. Compare yields from native against introduced species. Evaluate harvesting, transportation and utilization of biomass. Examine portions of yield as potential feed stuff. Model economic comparisons from land preparation to utilization.

APPROACH: In randomized design measure growth rate and sporuting ability for coppice harvest. Include fertilizer and spacing trials. Determine BTU content. Maintain untreated areas of uncultivated species for yield comparisons. Evaluate possible cultivation and harvesting techniques. Compare known transportation and utilization costs with projected acre-yields. Analyze bark and foliage samples for feed value.

SUPPORTED BY Vermont State Government

2.0261,

CONVERSION OF LIGNOCELLULOSE BY THERMOPHILIC ACTINOMYCETES MICROORGANISMS

D.L. Crawford, George Mason University, School of Arts & Sciences, Dept. of Biology, *400 University Dr., Fairfax, Virginia* 22030

Lignin and cellulose are the two most abundant naturally occurring organic materials on earth and potentially represent important industrial raw materials. Further, as a result of man's increased utilization of these resources, lignin, cellulose and the derived complex lignocellulose, are becoming a major waste disposal problem. Despite the need for a thorough understanding of the microbiological decomposition of lignocellulose, it is presently an incompletely understood phenomenon. The role of bacteria, in particular, in this process has not yet been defined. Preliminary evidence indicates that certain species of thermophilic actinomycetes bacteria actively attack lignocellulose, but little is known about the lignocellulose degrading abilities of the group as a whole. The goal of this research program is to examine the lignin, cellulose and lignocellulose decomposing abilities of this group of bacteria. A large number of strains will be isolated and characterized as to their abilities to attack lignin, cellulose and the lignicellulose complex. These studies will define the roles of this group in lignocellulose decomposition. In addition, selected isolates will be used in optimization studies in which the more important parameters for lignocellulose decomposition will be determined. These studies will be a prelude to future work aimed at developing microbiological or enzymatic systems for converting lignocellulose materials into useful food, chemicals, and fuels.

SUPPORTED BY U.S. National Science Foundation, Div. of Advanced Environmental Research & Technology

2.0262,

THE PHOTOSYNTHESIS ENERGY FACTORY

M.D. Fraser, Intertechnology Corp., *P.O. Box 340, Warrenton, Virginia* 22186

An integrated factory could accept wood and municipal sewage, operating a power plant to generate steam, grow algae on sewage and carbon dioxide from the power plant, digest algae and other organic solids to methane, and recycle nutrients, minerals, and waste waters to the forests. Credits would come from waste disposal and from the synergism of the elements of the factory. Waste heat from the power plant would warm the algae ponds to increase productivity which should be extremely high because of CO-2 enrichment. Steam, electricity, pipeline gas, and minor byproducts should be an economical product mix. This project will evaluate the problems in interfacing a power plant to algal ponds. Energy flows and economics will be analyzed. Through a subcontract to Dr. William Oswald, University of California, Berkeley, algae will be grown on sewage and stack gases or treated stack gases. Digested algae with or without fly ash will be evaluated for fertilizing trees. A suitable site for a full-scale plant will be selected and plans for commercialization of the concept will be prepared.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0263,

DEMONSTRATE THE FEASIBILITY OF A FUEL PLANTATION AS A NEW SOURCE OF ENERGY

E.O. Mariani, Marelco Inc., *3900 Mt. Vernon Ave., Alexandria, Virginia* 22305

Eucalyptus trees are faster growing than almost any others when appropriate conditions prevail. In Argentina, eucalyptus plantations are operated commercially for production of charcoal needed for manufacturing steel. Of several hundred species, only a few can thrive in climates that are sometimes cold. This project will prepare for field testing of eucalyptus species in various warm locations of the U.S. Sites will be selected, appropriate species will be identified, and the research plan will be refined. Another important task is preparation of engineering drawings and specifications for the growing site and for required buildings.

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0264,

SYSTEMS STUDY AND PROGRAM PLAN FOR SILVICULTURE ENERGY PLANTATIONS

R.P. Pikul, Mitre Corp., *1820 Dolley Madison Blvd., McLean, Virginia* 22101 (E(49-18)-2081)

A systems analysis of the Silvicultural Energy Plantation concept is underway. The Georgia-Pacific Corporation assists Mitre by supplying data on land availability, quantity and nature of forest residues, growth rates of a broad range of indigenous and exotic species, management requirements, and production costs. This data is integrated with Mitre's analyses of regional economics, environmental impacts, regional and national energy supply and demand projections, and economic and technical review and evaluation of promising conversion processes (combustion, thermochemical, and biological). A systems model is being developed to determine which system configurations, if any, will be best suited to each of the eight National Forest System Regions, in terms of tree species, management practices, conversion process, and product mixes. Several site specific case studies will be performed in the most promising regions. Specific recommendations will be made regarding advanced and applied research needed to improve viability of the concepts studies. Additionally, plans will be formulated for pilot and demonstration projects to prove technical and economic feasibility of silviculture-based energy production and thus enhance its commercialization potential. (ERDA 76-137)

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0265,

A TECHNOLOGY ASSESSMENT OF TERRESTRIAL BIOMASS SYSTEMS

D.J. Salo, Mitre Corp., Metrek Divsion, *1820 Dolley Madison Blvd., McLean, Virginia* 22101

Terrestrial biomass is potentially capable of providing a constant supply of significant quantities of fuel and chemicals. There are technologies for biomass production, biomass conversion, and product distribution and utilization systems. Should these technologies be widely adopted and significantly change the present farming patterns, this would lead to important institutional consequences. Issues and impacts which could stem from land acquisition and utilization, biomass fuel and chemical costs, and the effects of biomass technologies on the environment are among those that require assessment. Representative biomass technologies will be selected for assessment and a framework for analysis will be developed. Both technological and nontechnological future impacts will be identified and evaluated assuming a set of baseline conditions.

It is anticipated that private and government decision makers will be utilize the results of the assessment as they develop policies to cope with impacts of biomass technologies on society. Results of the analysis will be of value in developing investment, commercialization, and research and development programs.

SUPPORTED BY U.S. National Science Foundation, Div. of Policy Research & Analysis

2.0266,

OPTIMIZATION OF METHANE PRODUCTION FROM SLUDGES GENERATED IN PHYSICO-CHEMICAL WASTEWATER TREATMENT PROCESSES

D.S. Lent, U.S. Dept. of Defense, Army, Mobility Equipment Research & Development Command, *Fort Belvoir, Virginia* 22060

Determine the feasibility of anaerobic digestion on physico-chemical sludges. Optimize the production of methane using anaerobic digestion of the sludges. Evaluate potential feasibility by looking at the basic characteristics of the sludge. Optimize variables such as temperature and retention time for maximum methane production with minimal digestor volume. Study the environmental impact of the digested sludge on the environment. Design a continuous anaerobic reactor.

SUPPORTING AGENCY ADDRESS INFORMATION: AMC Sanitary Sciences Division, Ft. Belvoir, Va. 22060.
SUPPORTED BY U.S. Dept. of Defense, Army

2.0267,

DEVELOPMENT OF LUBRICATION TECHNOLOGY FOR ALCOHOL AND OTHER SYNTHETICALLY FUELED SPARK IGNITION ENGINES

Unknown, U.S. Dept. of Defense, Army, Mobility Equipment Research & Development Command, Fuels & Lubricants ,Research Lab., *Fort Belvoir, Virginia* 22060

Investigation of lubricant performance, reliability and interaction with fuels, combustion products and engine materials when used in various heat engines with various alternative fuels used in place of gasoline. Present activities relate to the use of alcohol and alcohol/gasoline blends and include resolution of any deficiencies and problems that may exist.
SUPPORTED BY U.S. Dept. of Energy, Div. of Transportation Energy Conservation

2.0268,

BENCH-SCALE RESEARCH IN THE THERMOCHEMICAL CONVERSION OF BIOMASS TO LIQUID FUELS

P. Walkup, Battelle Memorial Inst., Pacific Northwest Laboratories, *P.O. Box 999, Richland, Washington* 99352 (E(45-1)-1830)

Experiments will be run to establish operating parameters for the Albany Wood Waste-to-Oil pilot plant. Specific objectives are to identify product oil stability, determine pressure requirements, and help formulate supportive research for the Albany plant to be implemented at PNL. Samples of the recycle oil will be furnished to PNL where tests will be run on polymerization properties, chemical characteristics, and stability to determine the number of recyclings that are practical. Reactor pressure will be studied to see if the system can be operated under low pressure. In the tests, pressure will be varied by removing water vapor from the system or by CO and inert gas variation. (ERDA 76-137)
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0269,

WOOD CONSTRUCTION CONCEPTS

J.B. Grantham, U.S. Dept. of Agriculture, Forest Service, Pacific Northwest Forest & Range Experiment Station, *Seattle, Washington* 98105 (PNW-3501)

OBJECTIVE: Advance the effective use of wood in building construction through development of technical guides involving function, design, and fabrication or erection of structures.
APPROACH: General: Develop concepts or systems of construction that enable wood to effectively satisfy recognized needs. Problem areas: Improve acoustical and vibrational performance of lightweight wall and floor systems. Compare sound insulation & vibration measured in buildings with that predicted by laboratory measurement. Investigate reasons for differences. Support laboratory evaluations of promising new construction systems. Increase material efficiency with building systems or components. Encourage & support studies of building systems or components that promise economies in the construction of institutional, commercial, or residential buildings. Decrease annual maintenance costs of economical wood systems by better protection of exposed wood through design, finishing or treating. Collaborate with the Forest Products Laboratory and others to extend our knowledge of designs, finishes, and treatments that protect exposed wood-particularly through exposure of structures, sections, panels, etc. at the Olympia exposure site.
PROGRESS: Investigated with the Forest Residue Reduction Program, and Forest Products Laboratory, the feasibility of producing electrical energy or products from wood residue. Available mill & logging residue are suited to supplement wood fiber supplies and replace fossil fuels at forest industry plants. Costs of collecting logging residue must be partially offset by credits for disposal, if large scale use of logging residue is to be achieved. Well sealed storm windows were more effective than double glass panes in improving sound insulation against traffic noise. A subjective method of masking the transmitted sound of live footfalls on wood floor-ceiling assemblies was developed and applied to six floors. Additional designs to prevent water accumulation in end grain of exposed wood decks or heavy structural timbers have been developed. Guides to construction details, treatments, and finishes for exposed wood decks have been published. Promising new ways of protecting deck members or exposed ends of timber beams are under investigation.
SUPPORTED BY U.S. Dept. of Agriculture, Forest Service, Pacific Northwest Forest & Range Experiment Station

2.0270,

DEVELOPMENT OF SYSTEMS MODELS ADAPTABLE TO THE STUDY OF FOREST LAND USE AND FOREST UTILIZATION PROBLEMS IN THAILAND

J.S. Bethel, University of Washington, School of Forest Resources, Dept. of Management & Social Sciences, *t t5 Anderson, Seattle, Washington* 98195

This award is in partial support of work undertaken by the staff of the College of Forest Resources, University of Washington, to adapt and extend the Tropical Forest Utilization System (TFUS) to develop a rational forest land use program applicable to northern Thailand. The integrating component of TFUS is a Reference Materials System, which uses a series of simulation models to represent the structure of a forest and relevant conversion facilities. The National Research Council of Thailand will support the work of scientists from Kasetsart University in Thailand in this project. Specific work undertaken will include analysis of growth and stand data and development of additional utilization models to incorporate local consumption of wood for fuel and options for producing fuel wood. An introductory phase of this study was supported under NSF award INT 7608937.
SUPPORTED BY U.S. National Science Foundation, Div. of International Programs

2.0271,

CHEMICALS FROM WESTERN HARDWOODS AND AGRICULTURAL RESIDUES

K.V. Sarkanen, University of Washington, School of Forest Resources, *t t5 Anderson, Seattle, Washington* 98195

This award provides for incremental funding for the NSF continuing grant AER 77-08979 whose overall objective is to assess the potential of underutilized renewable resources such as hardwoods and agricultural residues for the production of useful chemicals. Specifically, the objectives are to: (a) characterize the essential properties of cellulose, hemicellulose, lignin and extractive componets of red alder wood and wheat straw; (b) examine novel methods for converting red alder wood and wheat straw to fibrous products in combination with by-product recovery; and (c) convert the lignin and carbohydrate by-products to chemicals using pyrolysis and microwave degradation. Research for this period focuses on organic solvent separations of lignocellulosic materials.
SUPPORTED BY U.S. National Science Foundation, Div. of Problem Focused Research Applications

2.0272,

EVALUATION AND MODELLING OF BIOMASS YIELDS FROM CONIFER STANDS IN INLAND NORTHWEST

R. Chapman, Washington State University, School of Agriculture, Dept. of Forestry & Range Management, *Pullman, Washington* 99163 (WNP00426)

OBJECTIVE: Development of individual tree biomass equations for each of the major softwood species in the Inland Northwest. Development of statistical models to describe the distribution of biomass within a stand for each tree component (boles, branches, and foliage) based on variety of utilization standards (top diameters), and the accumulation of biomass over time. Modification of existing volume simulators or development of new simulators which can be used to evaluate many alternative energy production stretegies such as optimum species selection and composition and selection of appropriate silvicultural treatments.
APPROACH: Stand representatives of species combinations, age classes and habitat types will be sampled in the field, and lab determinations made of oven dry yield. Statistical models will be designed to provide distribution of biomass within a stand for each tree component. These models will be used to strengthen existing volume simulators or if necessary for the development of new simulators, to evaluate alternative energy production strategies.
SUPPORTED BY Washington State Government

2.0273,

INVESTIGATION OF PELLETIZED WASTE WOOD PRODUCT AS FUEL SOURCE IN COAL FIRED BOILERS

W. Leonard, Western State Hospital, *Steilcoom, Washington* 98388

The coal fired boilers at Western State Hospital, Steilacoom, Washington have been operating under variance for violation of atmospheric emission standards. A pelletized wood product manufactured under the name 'Woodex' has been tested in the unmodified boilers with considerable success. The results of tests so far concluded indicate complete compliance with all applicable standards at a cost per therm lower than any other available source of energy. The Woodex product will be used as the primary fuel in the main boilers on a pilot basis for the coming heating season.
SUPPORTED BY Washington State Government

2.0274,

ENERGY CONSERVATION AND INCREASED PRODUCTION SYSTEMS

M.D. Robison, Weyerhaeuser Co., *t t th & A Sts., Tacoma Bldg., Tacoma, Washington* 98401

Description: Studies include elumination of steam leaks, conduction of heat and material balances of process units, indentification of where energy savings can be implemented, improvement of powerhouse efficiencies, recovery of low level heat, use of insulation to conserve heat, use of heat exchange equipment for heat economy, reduction of boiler blowdown, collection and return of condensate to boiler, recovery of heat from process vents, heat saving designs for new plants, use of wood residuals for energy production, feasibility of energy plantations, wood residual gasification, geothermal possibilities, oil and gas well exploration on own properties, and development of new technology for more efficient energy utilization.
Addenda: Estimated calendar year funding reported as 1974 $1,500,000, 1975 $600,000.
SUPPORTED BY Weyerhaeuser Co.

2.0275,

THE ROLE OF MICROORGANISMS IN WASTE DISPOSAL

P.G. Moe, West Virginia University, School of Agriculture & Forestry, Dept. of Plant Sciences, *Morgantown, West Virginia* 26506 (WVA00244)

OBJECTIVE: Study: Anaerobic digestion for disposal of wastes generated in a family dwelling unit; disposal of effluent and sludge from community sewage disposal plants; generation of methane gas through the anaerobic digestion of animal manures; aerobic composting of manures; soil applications as a waste disposal system for industrial waste materials; disposal of acid mine drainage, and the disposal of industrial wastes in aquatic environments.
APPROACH: Laboratory and field experiments will be conducted of waste applications in aquatic and edaphic ecosystems. Systems will be evaluated for their microbiological populations and biological activity. Environmental factors will be manipulated to estimate optimum conditions for biological activity. Effects of toxicity, synergism and antagonism within the populations will be investigated.
PROGRESS: (1) We are evaluating the aerobic biodegradation of sanitary wastes generated in an individual family dwelling unit. (2) We are monitoring the biological nitrification occurring in a bench top aerobic media trickling filter apparatus being evaluated for tertiary treatment of municipal sewage. (3) We are evaluating the ability of soil microorganisms to detoxify industrial oily wastes being applied to cropped soils. We have found that oily wastes are rapidly degraded by normal soil microflora. (4) We are evaluating the influence of acid mine drainage on the microflora of fresh water streams. We have found that fecal streptococci, because of better survivability, are better indicators of fecal pollution than coliform bacteria in acidic ecosystems. (5) Simultaneous enumeration of coliform bacteria by most probable number and direct membrane filtration techniques in water samples collected from streams affected by acid mine water indicated that the recovery efficiency of the membrane filtration procedure was relatively poor. Substantially enhanced recovery of coliform bacteria resulted upon the application of

an enrichment step when using the membrane filtration procedure. (6) We also studied the survivability of Prototheca species in acid mine water contaminated streams. It was determined that Prototheca are not indigenous inhabitatns of fresh water streams and only survive a few days after being introduced along with organic pollutants into acid streams.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, West Virginia

2.0276,

ASSESSMENT OF METHODS FOR DIRECT CONVERSION OF AGRICULTURAL RESIDUES TO UTILIZABLE ENERGY FORMS

R.C. Bailie, West Virginia University, West Virginia Agricultural & Forestry Experiment Station, *Morgantown, West Virginia* 26506 (1090-16062-001-C)

OBJECTIVE: Provide a technical and economic assessment of conversion systems which may be used to convert agricultural residues to fuel for single farms or small agricultural communities.

APPROACH: This is a state-of-the-art evaluation to be based on existing data for the various processes and will include an analysis of the energy efficiency of each process alone, as well as the direct and indirect input. Processes to be evaluated will include direct combustion, anaerobic digestion, both thermophilic and mesophilic, for the production of methanes and alcohols, pyrolyiss - complete and partial, chemical reduction, hydro-gasification, catalytic gasification, enzymatic reduction, and combined hydrolysis fermentation.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Beltsville Agricultural Research Center

2.0277,

ENERGY AND ECONOMIC ASSESSMENT OF ANAEROBIC DIGESTERS AND BIOFUELS FOR RURAL WASTE MANAGEMENT

T.P. Abeles, Oasis 2000 Inc., *University Dr., Box 1, Rice Lake, Wisconsin* 54868

RESEARCH OBJECTIVES: 1. To study design and operational problems of commercially-constructed digesters and to develop creative and practical alternatives or modifications. 2. To develop methods of optimizing all products of the digestion process. 3. To develop optimization criteria for the integration of anaerobic digesters into rural and aquaculturally based environments. 4. To look at the legal, social, and political problems which may be created by large-scale digesters. 5. To conduct a systems analysis of environmental issues related to the processing of agricultural waste through anaerobic digesters. 6. To study the feasibility of producing alcohol to meet mobile fuel needs as part of the energy system on farms and in rural areas.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development

2.0278,

ENERGY AND CHEMICAL PRODUCTION FROM WOOD RESIDUES

G.J. Hajny, U.S. Dept. of Agriculture, Forest Service, Forest Products Lab., *P.O. Box 5130, Madison, Wisconsin* 53705 (FPL-3409)

OBJECTIVE: Foster efficient use of wood residues for chemicals and energy production by providing authoritative evaluation of available technology and developing improved techniques for chemical and biochemical conversion and fuel uses of wood.

APPROACH: In the area of chemicals, three subjects will be investigated: The fractionation or solubilization of wood components, the hydrolysis (saccharification) of cellulose, and the further conversion of saccharification products to more useful materials. The first year's work will include critical reviews of available technology and of past research findings. On the subject of wood fuels, a summary review of past work at the Forest Products Laboratory will be prepared. Next, updated reports on technology for briquetting and charcoal production will be published.

SUPPORTED BY U.S. Dept. of Agriculture, Forest Service, Forest Products Lab.

2.0279,

FOREST RESIDUES ENERGY PROJECT--DIRECT BURNING

R.A. Arola, U.S. Dept. of Agriculture, Forest Service, North Central Forest Experiment Station, *Rhinelander, Wisconsin* 54501

A principal cooperative effort on Forest Residues for Energy is underway between the Forest Service and DOE. The program is in its second phase, with the North Central Forest Experiment Station working with several pulp and paper companies. The objective is to quantify and characterize forest residues available in northern Wisconsin and Michigan and determine the delivery cost of these residues. The economic and simulation model methods developed in this study will allow forest industry in other parts of the country to evaluate the potential of converting from fossil fuels to residue wood as an energy source. The recovery of tops and limbs from sawlog operations in preliminary field trials with a prototype topwood harvester indicated costs of about $2 per ton to prepare tops for skidding, an average recovery of one green ton per hardwood sawlog top, and a productivity of one-half acre per hour. Growth and damage evaluations over three growing seasons on the previously mechanized thinned hardwood stand indicate that the stand is responding favorably. Commercial application of the mechanized thinning research has taken place.

SUPPORTED BY U.S. Dept. of Energy

2.0280,

MAXIMUM YIELD OF INTENSIVELY CULTURED PLANTED STANDS FOR WOOD PRODUCTS AND ENERGY PRODUCTION

D.H. Dawson, U.S. Dept. of Agriculture, Forest Service, North Central Forest Experiment Station, *Rhinelander, Wisconsin* 54501 (NC-1152)

OBJECTIVE: Develop the most efficient and economically feasible method of producing maximum wood and biomass per acre from planted stands and determine their properties.

APPROACH: Select woody species or species variants showing rapid juvenile growth, ease of reproduction and good prospects for genetic improvement. Using intensive culture, determine effects of various spacings, rotations, nutrient levels and irrigation on biomass yields and quality of tree components.

PROGRESS: One-year-old shoots of Populus clones grown under intensive culture at three dense spacings produced yields between .57 and 6.29 tons of dry wood per acre. The highest yields were obtained from cuttings planted at the closest (9 inch x 9 inch) spacing. At the end of two years the closest spaced plot produced at the same per acre/per year rate but annual production for the wider spaced (21 inch 24 inch) plot increased considerably. A growth and yield model projected the closer spaced stands outproducing the more widely spaced stands for at least ten years. Yields produced by the dense plots indicate an extremely high degree of capability, compared with other woody and herbaceous plants in utilizing available solar energy. Studies of containergrown seedlings showed that in comparison with other soil media, peat moss and vermiculite mixes produced red pine and white spruce seedlings at least 30% larger than seedlings from any other mix tested. Outplanted seedlings from these mixes also survived best. Activity and expression of peroxidase, an inductible enzyme, were found to be indicators of growth rate in Populus, hence can be used as a rapid selection tool. The fastest growing clones tested had initially the lowest total activity, while the slowest growing had the highest peroxidase activity. At the final harvest times the reverse was true.

SUPPORTED BY U.S. Dept. of Agriculture, Forest Service, North Central Forest Experiment Station

2.0281,

MAXIMUM PRODUCTION OF BIOMASS FOR ENERGY

J. Zavitkovski, U.S. Dept. of Agriculture, Forest Service, North Central Forest Experiment Station, *Rhinelander, Wisconsin* 54501

Research is aimed at development of methodologies and strategies for establishing fuel plantations of fast growing forest tree species on short rotations and under intensive cultural practices. Management strategies focus on maximizing the total biomass production per unit of land using selected genetic varieties of poplar and eucalyptus with high wood density and high caloric value per unit volume. Limited tests indicate a potential of 15 to 20 dry tons per acre per year. Biomass produced under this management system can be used directly for energy production or used as raw material for production of petrochemical substitutes.

SUPPORTED BY U.S. Dept. of Energy

2.0282,

INTENSIVELY CULTURED PLANTATIONS FOR BIOMASS AND ENERGY PRODUCTION

J. Zavitkovski, U.S. Dept. of Agriculture, Forest Service, North Central Forest Experiment Station, *Rhinelander, Wisconsin* 54501 (NC-1112)

OBJECTIVE: Develop the most efficient and economically feasible method establishing planted stands and producing maximum wood and biomass per acre from them.

APPROACH: Select woody species or species variants showing rapid juvefile growth, ease of reproduction and good prospects for genetic improvement. Using intensive culture, determine effects of various spacings, rotations, nutrient levels and irrigation on biomass yields.

SUPPORTED BY U.S. Dept. of Agriculture, Forest Service, North Central Forest Experiment Station

2.0283,

IMPROVING SURFACE WATER CONDITIONS THROUGH CONTROL AND DISPOSAL OF AQUATIC VEGETATION

H.D. Bruhn, University of Wisconsin, Madison Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *116 Agricultural Hall, Madison, Wisconsin* 53706 (WIS05032)

OBJECTIVE: Increase aquatic vegetation harvesting equipment capacity, reduce harvesting costs, and develop methods and procedures for utilizing aquatic vegetation.

APPROACH: New theories of harvesting methods are being investigated. Laboratory studies are being made of new types of functional components of harvesting equipment. Prototypes of promising equipment are being constructed and tested in the lake. Processing of aquatic vegetation is being investigated to determine its feeding value after processing and methods of increasing palatability.

PROGRESS: The major progress during the past year was in the areas of increasing aquatic vegetation harvest capacity and in providing material for methane generation. New gathering devices were developed for the collection of precut aquatic vegetation. Harvesting costs were determined for two types of modified commercial systems being operated by Dane County. Their highest capacity harvesting unit with the lowest operating cost per acre harvested was equipment previously modified according to our recommendations. With our newly developed gathering equipment further increase in capacity is possible. Between two and three times more area can be harvested with a given rate of travel and the major previous limit on travel rate is largely eliminated in our new experimental equipment.

SUPPORTED BY Wisconsin State Government

2.0284,

MICROBIAL OXIDATION OF METHANE

R.S. Hanson, University of Wisconsin, Madison Campus, Agricultural Experiment Station, Dept. of Bacteriology, *116 Agricultural Hall, Madison, Wisconsin* 53706 (WIS01887)

OBJECTIVE: Isolate and characterize methane oxidizing bacteria, to study their ecology and physiology and develop fermentation systems for the production of useful products from waste methane.

APPROACH: Organisms capable of growth on methane as the sole carbon and energy source will be isolated on a mineral salts medium with gas phases containing methane. Their physiology, including cytology (electron microscopy) metabolism (using enzymological techniques and isotopic tracer methods) will be studied. Pilot fermentors using farmlot wastes will be used to produce methane which will be utilized in pure culture fermentations with wild type strains and mutants of methane oxidizing bacteria for the production of commercially useful products. The ability of these organisms to synthesize and accumulate methylmercury will be examined.

PROGRESS: Several new facultative methylobacteria have been isolated. The fine structure of the organisms has been studied and the pathways for carbon assimilation and sugar oxidation have been determined. The growth requirements of some pure cultures and stable mixed cultures have been studied

in order to determine the most suitable isolates for applied uses in single cell protein and amino acid biosynthesis.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Wisconsin

2.0285,

TREATMENT OF FARM MANURE AND ORGANIC WASTES

R.S. Hanson, University of Wisconsin, Madison Campus, Agricultural Experiment Station, Dept. of Bacteriology, *116 Agricultural Hall, Madison, Wisconsin* 53706 (WIS05092)

OBJECTIVE: Design and test a system for the bioconversion of organic wastes to methane and other useful products.

APPROACH: An anaerobic fermenter suitable for a 15 animal confined dairy unit will be designed and the conditions for optimum production of methane will be determined. Additional units for gas purification and water purification by photosynthetic and methylotrophic bacteria will be designed and conditions for optimal production of soil conditioners and/or single cell protein will be determined.

PROGRESS: Thermophilic, anaerobic bacteria that actively degrade cellulose were isolated. They were identified as Clostridium thermocellum. The bacteria produce an exocellular cellulase which was partially purified. The enzyme is 0(2) sensitive, stable at 70 C, and has a pH optimum of 5.2. These bacteria and their cellulase have potential for industrial scale use in converting cellulose into ethanol, acetate and microbial biomass. A mixed culture of the cellulose degrading bacteria and methane-producing bacteria efficiently converted cellulose to CH(4) and shows promise as a system for microbial energy conversion from cellulose wastes. The residue from centrifugation of cow and poultry manures which have been digested anaerobically contain, respectively, 10.2 and 31% of their dry weights as protein. The supernatant fluids contain high concentrations of acetic, propionic, and butyric acids. A mixed culture of photosynthetic bacteria grow on substrates in these liquids when exposed to light. The cell yields as protein are 20 and 24%, respectively, of the dry weight of dry cow and chicken manure. The total production of protein resulting from anaerobic fermentation and growth of photosynthetic bacteria is 30.2% of the dry weight of cow manure, 55% of the dry weight of chicken manure. A high frequency transformation system has been developed for Methylobacterium organophilum. This is the first workable system for genetic analysis of a methane oxidizing bacterium.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Wisconsin

2.0286,

ANAEROBIC CONVERSION OF ORGANIC WASTES INTO METHANE BY THERMOPHILIC BACTERIAL ASSOCIATIONS

J.G. Zeikus, University of Wisconsin, Madison Campus, Agricultural Experiment Station, Dept. of Bacteriology, *116 Agricultural Hall, Madison, Wisconsin* 53706 (WIS01957)

OBJECTIVE: Improving the anaerobic digestion process currently employed in biological waste treatment. The important bacterial species responsible for the anaerobic decomposition of organic waste will be isolated and characterized. Thermophilic species with high metabolic activities will be selected and the feasibility of using them to convert agricultural wastes into methane determined.

APPROACH: Bacterial enrichment cultures containing innocula from various sediment systems that are active in anaerobic decomposition of organic matter will be incubated at mesophilic and thermophilic temperatures. Pure cultures of important bacterial species will be isolated by the Hungate anaerobic culture technique and their physiological properties determined. Associations of thermophilic bacteria which possess high metabolic activities will be added to agricultural wastes in a model digestor. Important parameters which may influence the rate of digestion and methane production will be determined.

PROGRESS: A thermophilic methane biocenosis has been developed. Cellulosic wastes obtained from agriculture, industry and other sources are converted to methane by an association of anaerobic bacteria. Individual members of the biocenosis have been isolated and include new species of cellulolytic and methanogenic bacteria. Physiological characterization of these anaerobic thermophiles has been initiated. Work in progress will optimize the conditions for bioconversion of cellulosic wastes in a model digestor.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Wisconsin

2.0287,

MICROBIAL ECOLOGY OF METHANE FORMATION

J.G. Zeikus, University of Wisconsin, Madison Campus, School of Agriculture & Life Sciences, Dept. of Bacteriology, *Agriculture Hall, Madison, Wisconsin* 53706

This work is a continuing study of the ecology and physiology of methanogenic bacteria with a view towards understanding carbon and nutrient cycling ecosystems. The studies are centered primarily in Lake Mendota, Wisconsin but work is now being initiated in other environments that include merimictic lakes, acid bogs and marsh lands in Wisconsin, thermal springs, and sediments in Yellowstone National Park, and wetwood in living hardwood trees. The ultimate goal of this research is to be able to (1) describe how the environment influences and controls methanogenesis, (2) define the principles involved in conversion of substrates to methane and the role of electron flow in this process, and (3) to specify the interactions between methanogenic bacteria and other microbial species that account for the anaerobic decomposition/mineralization of organic matter.

SUPPORTED BY U.S. National Science Foundation, Div. of Environmental Biology

2.0288,

MICROBIAL ECOLOGY OF METHANOGENESIS

J.G. Zeikus, University of Wisconsin, Madison Campus, School of Agriculture & Life Sciences, Dept. of Bacteriology, *Agriculture Hall, Madison, Wisconsin* 53706

This work is a part of a continuing study of the ecology and physiology of methane bacteria, and of their role in the carbon cycle of freshwater ecosystems. The studies are centered in Winsconsin lakes (holomictic Lake Mendota and meromictic Knaack Lake). The goal of this research is to be able to 1) describe how the environment controls methanogenesis, 2) define the mechanism of conversion of substrates to methane and the role of electron flow in this process, and 3) determine how methane bacteria interact with other microbial forms in the processes of decomposition and mineralization of organic matter. This knowledge has considerable practical potential for the design of systems of controlled production of methane fuel by fermentation of organic wastes.

SUPPORTED BY U.S. National Science Foundation, Div. of Environmental Biology

2.0289,

MARKETING ANALYSIS AND ECONOMICS OF FOREST PRODUCTS UTILIZATION

T.H. Ellis, University of Wisconsin, Madison Campus, U.S. Dept. of Agriculture Forest Products Lab., *P.O. Box 5130, Madison, Wisconsin* 53706 (FPL-4201)

OBJECTIVE: Bring about more complete and efficient use of the Nation's timber resources by providing economic evaluations of opportunities for development and marketing of new or improved timber products and for introduction of technological advances in the processing, distribution, and use of timber products.

APPROACH: Standard investment analysis, using product output rates and efficiency estimates provided by Forest Products Laboratory scientists and consultants, price estimates based on current trade reports, and cost estimates based on industry association reports, consultant estimates, and engineering data.

PROGRESS: A computerized model of timber utilization, now partially completed, will allow rapid computation of timber and wood products requirements under alternative assumptions as to levels of economic activity, wood conversion technology, and regional distribution of production. The model copies the basic structure and wood-use coefficients reported in 'The Outlook for Timber in the United States'. Physical recovery factors of primary processing are employed to compute roundwood requirements and residue production associated with wood products requirements. Techniques for economic analysis of forest products manufacturing investments were developed in conjunction with on-going studies of particleboard and lumber manufacturing. These techniques include an adaptation of a computer program for calculating rates of return and net percent worth, before and after taxes, and a program for calculating variable costs of manufacturing particleboard. Further estimates were developed of energy potentials of wood residues in the U.S. Above-ground residues on 1973 logging areas were estimated to have been about 110 million tons of wood and 20 million tons of bark, oven-dry basis. Unused mill residues from sawmilling and plywood manufacture were estimated to have been about 10 million tons of wood and 7 million tons of bark in 1973. Use of all such waste for fuel would have met perhaps 3 percent of U.S. requirements. Use of wood and bark residues for fuels at forest industry mills appears increasingly attractive.

SUPPORTED BY U.S. Dept. of Agriculture, Forest Service, Forest Products Lab.

2.0290,

BIODEGRADATION OF WOOD

W.E. Eslyn, University of Wisconsin, Madison Campus, U.S. Dept. of Agriculture Forest Products Lab., *P.O. Box 5130, Madison, Wisconsin* 53706 (FPL-2202)

OBJECTIVE: Elucidate fundamentals of wood degradation processes as a base for improving control of such degradation. Devise on-site control measures using superficial treatments. Develop low-cost, nonpolluting termite controls.

APPROACH: Determine the fundamental mechanisms which cause differences in ability of certain types of decay fungi to attack hardwoods and softwoods through studies of the physiology, and particularly the enzymology, of white- and brown-rot fungi. Search for micro-organisms capable of selectively degrading lignin in wood. Isolate the microorganisms capable of selectively degrading lignin in wood. Isolate the microorganisms responsible for degrade in stored wood; study their physiological requirements, and investigate non-polluting avenues for their control. Field test the attractant-insecticide bait method for control of subterranean termites. Investigate chemically modified woods as regards their resistance to attack by drywood termites. Evaluate, through exposure studies, effectiveness of on-site preservative treatment of wood.

PROGRESS: The white-rot fungus, Coriolus versicolor, degraded cellulose in the absence of wood, whereas the brown-rot fungus, Poria placenta, did not use cellulose in the absence of wood indicating a decay inducer present in wood and not in isolated cellulose. Identification of these inducing factors would permit a significant breakthrough in control of wood decay. Six soft rot fungi isolated from wood chip storage piles utilized the carbohydrate fraction from alder and poplar in preference to lignin. Conversely, on pine Paecilomyces sp. and Thielavia terrestris removed lignin faster, characteristic of white-rot fungi. This basic information may determine the effects of fungi on pulp yields from stored chips and have possible application in wood bioconversion research. Anaerobic storage of aspen wood chips under water or in an atmosphere of 95% N 5% CO revealed no significant losses in wood yield or quality of pulp. The exclusion of oxygen would provide a safe environmental means of protecting wood chips during outdoor storage.

SUPPORTED BY U.S. Dept. of Agriculture, Forest Service, Forest Products Lab.

2.0291,

BIOCONVERSION OF LIGNOCELLULOSICS

T.K. Kirk, University of Wisconsin, Madison Campus, U.S. Dept. of Agriculture Forest Products Lab., *P.O. Box 5130, Madison, Wisconsin* 53706

Cellulose and lignin make up the bulk of the renewable organic material on earth and hence constitute abundant renewable resources. Biological conversion of those substances to food, sweeteners, chemical, fuels, etc. is attractive because of low conventional energy requirements, high efficiency, and environmental acceptability.

The objective of the proposed research is to convert cellulose and lignin by biological means to useful products. The hydrolysis of cellulose, a linear polymer of glucose, by cellulase enzymes results in the formation of glucose; the conversion of lignin, a complex polymer consisting of phenylpropane units linked together by a variety of chemical bond types, by ligninase enzymes may result in either desirable modified ligno-polymers or aromatic monomeric chemicals, i.e., benzonoid compounds. In nature, lignin and cellulose occur together, and the combina-

tion is known as 'lignocellulosics.' Specifically, the proposed research is to assess the feasibility of converting lignin, either in isolated form or in the combined natural state of lignocellulosic materials, to useful products via biochemical means. Concomitantly, research will also deal with converting cellulose to sugars, methane or single-cell protein. The cellulose enzymes produced by the active thermophilic anaerobic bacterium, Clostridium Thermocellum, will be isolated and characterized.

SUPPORTED BY U.S. National Science Foundation, Div. of Advanced Energy & Resources Research & Technology

2.0292,

PORTFOLIO OF SUCCESS STORIES IN CURRENT ECONOMIC USE OF BIOMASS ENERGY

E.E. Robertson, Biomass Energy Inst. Inc., *304 870 Cambridge St., Winnipeg, Manitoba, Canada*

The purpose of this was to develop a publication (camera-ready copy) for NTIS so that the intelligent layman, particularly those in decision-making levels in government, industry and the academic communities would have at their fingertips a consolidated picture of the considerable extent to which fuels from biomass are already being used. Knowing this, perhaps a larger proportion of available R.D. and D. resources will be applied to expanding on current successful methodologies rather than all on hypothetical prospects.

SUPPORTED BY U.S. Dept. of Energy

2.0293,

CONTINUATION OF THE STUDY OF THE FEASIBILITY OF USING METHANE GAS PRODUCED FROM ANIMAL WASTE FOR ENERGY PURPOSES

H.M. Lapp, University of Manitoba, Dept. of Agricultural Engineering, *Winnipeg, Manitoba, Canada* R3T 2N2

No summary has been provided to the Smithsonian Science Information Exchange.

SUPPORTED BY Canadian Dept. of Agriculture

2.0294,

ALTERNATIVE FUELS FOR VEHICLES USE

D. Elliott, Ontario Ministry of Transportation & Communications, *1201 Wilson Ave., Downsview, Ontario, Canada* M3M 1J8 (164794 (HRB NO.))

The short term objectives of the project involve the development and testing of gasoline/methyl fuel mixtures. The issues of vehicle performance and driveability as well as possible damage to vehicle components will be investigated. The longer term objectives involve emissions testing, an energy efficiency and economics study and investigation of methyl fuel alone in modified engines. /RTAC/

SUPPORTED BY Ontario Ministry of Transportation & Communications

2.0295,

CATALYSIS, THERMODYNAMICS, POLYMER RHEOLOGY AND UTILIZATION OF RESOURCES

J.F. Mathews, University of Saskatchewan, Dept. of Chemistry & Chemical Engin, *Saskatoon, Saskatchewan, Canada*

CURRENT AREAS OF RESEARCH AND STUDY: a. Conversion of aspen poplar to a feed for ruminant animals. b. Conversion of aspen poplar to sugars and protein. c. Conversion of aspen poplar to liquid heavy fuels. d. Recovery of heavy hydrocarbons from tar sands deposits. e. Degradation of polymers by ultrasonics.

POTENTIAL AREAS OF RESEARCH, STUDY OR POTENTAL INTEREST: a. Gasification and methanation of lignite. b. Mechanical properties of semi-crystalline polymers.

OTHER AREAS OF PAST RESEARCH EXPERIENCE: a. P-V-T properties of gas mixtures - measurements. b. Polymerization processes - kinetics and reac•or design. c. Mechanical properties of polymers at small deformations.

SUPPORTED BY University of Regina

2.0296,

BIOGAS FROM ORGANIC WASTES, ESPECIALLY MANURE OF DOMESTIC ANIMALS

Unknown, Danish Engineering Academy, Lab. of Industrial Chemistry, *Copenhagen, Denmark*

No summary has been provided to the Smithsonian Science Information Exchange.

SUPPORTED BY Government of Denmark

2.0297,

ENERGY UTILIZATION AT GYLLE

Unknown, Den Kongelige Veterinaer og Landbohojskole, Agricultural Engineering Inst., *Bulowsvej 13, DK1870 Copenhagen, Denmark*

During the work at the Agricultural Engineering Institute Report No. 24, 'Recovery of Heat in Agriculture', it was discovered that this is a very promising possibility. At present the studies involve the utilization of the energy in stable manure for heating the dwellings and water on farms.

SUPPORTED BY Government of Denmark

2.0298,

RESEARCH UPON DIFFERENT POSSIBILITIES OF PRODUCING ENERGY FROM STRAW

H. Schulz, Technische Universitat Munchen, *Theresienstr. 90, D8000 Munich 2, Bayern, Federal Republic of Germany*

DESCRIPTION OF PROJECT: OBJECTIVE: Experiment tests of plants for producing energy from straw; further development of these plants; construction of hot-air generators for drying plants by utilizing the combustion of the straw; carbonization of the straw in order to separate important elements and for the winning of straw coal.

WORK PROGRAM: a) Determination of the calorific value of different sorts of straw according to their varying moisture contents. b) Measurements at existing straw furnaces (heating capacity and efficiency). c) Improvements of the furnaces considering physical points of view and the efficiency of their work. d) Construction of a plant for burning huge bales (500 kg/bale). e) Development of simple plants for decomposing huge bales. f) Construction of hot-air generators for drying purposes (1. Combined plants for heating homes with boiler and interchange of heat. 2. Steel plant for interchange of heat without water circulation including the direct heating by selective connecting. 3. High-capacity combustion of huge bales.) g) Carbonization of straw; use and improvement of a plant developed by Dipl.-Ing. Linneborn.

RELATION TO OTHER WORKS: The work is based on existing Passat straw furnaces and plants designed by Dipl.-Ing. Linneborn; moreover, collaboration is held with the Institut fur Landmaschineenforschung of the Agricultural Research Centre in Braunschweig-Volkenrode where the basic studies of combustion of straw are made.

STATUS: Determination of the calorific value of different sorts of straw was made with the aid of a calorimeter.

Fundamental analysis of straw and ashes are in hand. Heating capacity and efficiency of 1 Passat furnace and 3 Linneborn furnaces are in hand. 2 movable hot-air generators for drying plants are ready, 1 transport vehicle for huge bales was constructed. Experiments with supporting fires began in order to reduce the smoke emission when lighting the fire.

ADDENDA: Performing organization: Bayerische Landesanstalt fuer Landtechnik, TU Muenchen.

SUPPORTED BY Bundesministerium fur Forschung und Technische

2.0299,

CONVERSION OF HALOPHILIC ALGAE TO OIL

R. Ikanm, Hebrew University of Jerusalem, Natural Products Lab., Dept. of Organic Chemistry, *P.O. Box 499, Jerusalem, Israel*

Halophilic algae are converted to oil by heating under pressure in saline media and in the presence of cheap catalysts and reducing gases such as hydrogen and carbon monoxide. The conversion product can be refined by distillation to produce hydrocarbons, or directly used as fuel oil.

SUPPORTED BY Ministry of Commerce & Industry

2.0300,

ANAEROBIC FERMENTATION OF INDUSTRIAL AND MUNICIPAL EFFLUENT AS A MEANS FOR PURIFICATION OF WATER AND METHANE PRODUCTION

P.M. Heertjes, Technische Hogeschool Delft, Dept. of Chemical Engin, *Kleuyverweg 1, Delft, Netherlands*

Compared with aerobic treatment, anaerobic treatment of waste waters has the advantages that methane is produced, no energy is needed to supply oxygen, and less surplus sludge of a better quality is produced. At present, disadvantages of the anaerobic treatment are the unreliability of the process and the problems involved in separating the gas from the microbial mass. These aspects are studied.

The research is carried out in collaboration with the Agricultural University at Wageningen (Professor Dr. P.G. Fohr, Dr.ir. G. Lettinga), where more concentrated wastes are studied.

SUPPORTED BY Technische Hogeschool Delft

2.0301,

APPARATUS FOR FERMENTATION OF ORGANIC MATERIAL TO PRODUCE METHANE FOR DEVELOPING COUNTRIES

S.P. Bertram, Technische Hogeschool Eindhoven, Dept. of Chemical Engin, *Insulindelaan 2 Postbus 513, Eindhoven, Netherlands*

No summary has been provided to the Smithsonian Science Information Exchange.

SUPPORTED BY Foundation Tool

2.0302,

HEAT BALANCE, TRANSMISSION OF LIGHT AND DIFFUSION RESISTANCES IN THE LEAVES OF POPLAR AND OF OTHER PLANTS

G.A. Pieters, Wageningen Center of Agricultural Sciences, Res Team on Physio of Plants, *10 Salverdaplein, Wageningen, Netherlands*

The object is to obtain a better understanding of the interactions between the individual plant and its surroundings. The influence of the root environment is a complicating factor in this respect. An understanding of the behaviour of the individual plant may improve our insight in the interaction between the plant and vegetation, which may be useful in relation to cultivation and improvement.

These plants will be cultivated under different conditions of light intensity, temperature, and root environment.

Addenda: Supporting agency and Performing organization: Landbouwhogeschool.

SUPPORTED BY Wageningen Center of Agricultural Sciences

2.0303,

ENERGY BALANCE OF POPLAR & OTHER PLANTS IN SITU, ON THE RATES OF PHOTOSYNTHESIS & RESPIRATION & THE TRANSPORT OF ASSIMILATES (ABBREV)

G.A. Pieters, Wageningen Center of Agricultural Sciences, Res Team on Physio of Plants, *10 Salverdaplein, Wageningen, Netherlands*

The object is to obtain a better understanding of the mechanism of production, distribution and utilization of photosynthetic products in the plant. So an explanation may be developed regarding the controlmechanisms of growth in the plant itself and of the behaviour of the plant as part of the vegetation. An exact understanding of the physiology of plants as part of the vegetation may be of profit in relation to cultivation and improvement.

Addenda: Supporting agency and Performing organization: Landbouwhogeschool.

SUPPORTED BY Wageningen Center of Agricultural Sciences

2.0304,

OPTIMIZATION OF ANIMAL WASTES TREATMENT WITH REFERENCE TO BIOTREATMENT, RECOVERY OF GAS, PROTEINS AND AGRICULTURAL UTILIZATION OF EFFLUENTS

J.A. Oleszkiewicz, Research Inst. on Environmental Development, Wroclaw Division, *Wroclaw, Poland* (L770D-2-20)

OBJECTIVE: The project will attempt to optimize the existing treatment system for a large hog farm and evaluate the production of bio-gas, production of protein and the production of yeast from the wastes.

Also land application of the effluent will be evaluated for possible ground and surface water contamination. The project will produce a report detailing the processes investigated, their efficiencies and the economics of each system. The initial laboratory scale work is complete. Field modification of the test treatment plant is scheduled for late 1978.
SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Robert S. Kerr Environmental Research Lab.

2.0305,
CONTROL SYSTEM FOR CONVERTING DIESEL ENGINES FOR OPERATION WITH SOLID FUELS
J. Abom, (No Performing Organization Reported), Poppelgatan 12 S42174 Frolunda, *Sweden*
By pulverizing solid fuels down to 0.1 mm particles, it is possible to obtain a fast enough combustion process to operate diesel engines. As energy density is fairly high, 0.3 - 0.5 kW h/kg, the use of solid fuels instead of oil may well prove profitable. The difficulty lies in adding the right quantity of fuel to the process fast enough. Through application of a vacuum acceleration system, a good control of the diesel engine is likely to be feasible.
By test running a diesel engine, with and without a precombustion chamber, the proper particle size will be determined for peat, wood, paper, bark, straw, brown coal and pit coal. Grinding and sifting equipment will be bought for this purpose. The experiments will be carried out at Chalmers University of Technology. A fuel mechanism has been constructed and control of powder injections with 0.00125 sec. injection time has been achieved by variable vacuum.
SUPPORTED BY Styrelsen for Teknisk Utveckling

2.0306,
SEALING ELEMENTS FOR DIESEL ENGINES OPERATING ON PULVERIZED SOLID FUEL
J. Abom, (No Performing Organization Reported), Poppelg 12 S42174 V Frolunda, *Sweden*
By hot-air drying of renewable fuels like wood, peat, straw, and reed, through the application of sun collectors, it is possible to pulverize solid fuels into powder at about Skr 0.20/kg. Diesel engines can be driven by such powder, provided that sufficiently durable sealing elements can be produced and a durable oil film separates the sealing elements from the mobile combustion chamber disc.
There is need for very good sealing, as the channel, in which there is a pressure of 20 MPa, has to be sealed so well that no air will penetrate into an adjacent channel and blow away the fuel powder. A special device for testing sealing elements as well as suitable lubricants will be developed.
SUPPORTED BY Styrelsen for Teknisk Utveckling

2.0307,
FREE BURNING CHIP - OIL BURNER INTENDED FOR OVERPRESSURE AND LOW-PRESSURE FIRING - MODULATED OPERATION
K. Andersson, (No Performing Organization Reported), *Sweden*
No summary has been provided to the Smithsonian Science Information Exchange.
SUPPORTED BY Styrelsen for Teknisk Utveckling

2.0308,
FIELD EXPERIMENTS ON SHORT ROTATION ENERGY FOREST (SALIX)
H. Johansson, (No Performing Organization Reported), *Sweden*
OBJECTIVE: Production of selected high performance species for large scale plantage.
APPROACH: A total of 300,000 plants (of which 240,000 are Salix Viminalis) will be cultivated under different irrigation and fertilization conditions. The soil is of poor, swampy type, unsuitable for agricultural usage. The location is middle Sweden. This project is closely related to project 3065 014 Short Rotation Forestry.
PROGRESS: Phase I of the project (53 3065 101) was severely disturbed by exceedingly heavy August rain. Any decisive results could not be obtained. In phase II the plantation will be completed under May 1978. Total plantage area amounts to 5 hectares.
INTENDED USE OF RESULTS: The results will be used within project 53 3065 014 for planned future escalation of field experiments. The project will be of importance for the full scale demo plants expected in 1981 - 1984.
SUPPORTED BY Namnden for Energiproduktionforskning

2.0309,
DEVELOPMENT OF WOOD-CHIPS FIRING
M. Nilsson, (No Performing Organization Reported), *Sweden*
No summary has been provided to the Smithsonian Science Information Exchange.
SUPPORTED BY Styrelsen for Teknisk Utveckling

2.0310,
DEMONSTRATION PROJECT AIMING AT A TRANSITION FROM OIL TO BIOMASS IN ENERGY PRODUCTION
S. Andersson, Allmanna Ingenjorsbyran Ab, *Box 5511, S11485 Stockholm, Sweden*
OBJECTIVE: The project concerned by this NRP regards a first stage in a study aiming to create a demonstration project showing how to transform an existing energy supply system based on oil into one based on biomass. The new system is intended to provide energy to two communities representing 3/4 of the Swedish population.
The first stage of the project will structurize a following more detailed study.
APPROACH: In this first stage, we will take an inventory of all factors and interests that in this particular case can affect the conception of the system. Such factors and interests are demands of energy, price questions, potential resources of biomass, roads, preservation of nature and environment etc. The system will include a wood-fired thermal power station for 25 MWel plus 60 MWth.
INTENDED USE OF RESULTS: The results gained in this first stage are intended to make it possible for the National Swedish Board for Energy Source Development to select systems for the supply of biomass energy to be studied in detail. They will also show how such a study could be done.
The final study will, in a practical way, show how to change an existing system of energy supply and will constitute a base for a possible decision in this change.
SUPPORTED BY Namnden for Energiproduktionforskning

2.0311,
NE-PROGRAM BIOSYSTEM, SUBPROGRAM RAW MATERIAL PRODUCTION - ENERGY FORESTS - INITIAL PLANNING
C. Ekberg, C G Ekberg Utvecklingstjanst Hb, *S18275 Stocksund, Sweden*
OBJECTIVE: Propose working program for subprogram 'Raw material production - energy forests'.
APPROACH: Involvement of key persons in a planning activity starting from a specified target in 1936. Dividing of the total work in main stages by identifying main decisions to be taken during the total period.
Preliminary description of main activities during identified stages.
Detailed description of working program for first stage.
Identifying of main connections with other subprograms. Considering possible parts for international cooperation.
INTENDED USE OF RESULTS: The National Swedish Board for Energy Source Development-NE will use the results for its future activities within the subprogram. By using the results, a faster development of this important part of Swedish energy supply is anticipated.
SUPPORTED BY Namnden for Energiproduktionforskning

2.0312,
POWDER ENERGY - PRODUCTION OF SUBSTITUTES FOR OIL FROM BIOMASS
J. Abom, Chalmers Tekniska Hogskola, Ship Design, *S40220 Goteborg 5, Sweden*
OBJECTIVE: Biomass from poplar, willow, reed, peat, straw, and forest waste products is ground and dried and then milled into a fine powder. The biopowder is used as fuel for steam boilers, heating furnaces, and diesel engines operating on powder.
APPROACH: Combustion plants for biopowder will be developed. Combustion takes place by impulse combustion according to a recently invented method.
- Financial support has also been received from the National Swedish Board for Technical Development.
PROGRESS: Diesel engines operating on powder, as well as heating furnaces, will be tested during the fall of 1978. Maximum output about 10 kW.
INTENDED USE OF RESULTS: Since biopowder can be produced at about 20% less cost than oil (current price Skr 750/ton of oil), substantial savings in foreign currency can be made and a number of jobs created by a changeover to combustion of biopowder.
SUPPORTED BY Namnden for Energiproduktionforskning

2.0313,
HANDLING SYSTEMS FOR SMALL AND MEDIUM SIZE ENERGY PLANTATIONS
H. Wahlforss, Ergonomi Design Ab, *Box 140 21, S16114, Bromma 14, Sweden*
OBJECTIVE: To develop equipment to handle energy plantations on small and medium sized sites.
APPROACH: After studies on handling problems and existing equipment, new ideas shall be developed. The integrated handling system will be presented in slide form.
PROGRESS: In the first phase, a systems approach is developed for the handling of energy plantations. Phase two includes tests with existing as well as newly developed components in cooperation with manufacturers. Phase three includes the production of prototypes.
INTENDED USE OF RESULTS: The result of phase 1 will form the basis for various system improvements as well as to suggest continued development work together with chosen manufacturers.
SUPPORTED BY Namnden for Energiproduktionforskning

2.0314,
PRODUCTION OF INFORMATION MATERIAL ON BIOSYNTHESIS FOR INTERESTED PARTIES
H. Wahlforss, Ergonomi Design Ab, *Box 140 21, S16114, Bromma 14, Sweden*
OBJECTIVE: The long-term goal is to give the board up-to-date information material concerning energy plantations as a source of energy.
APPROACH: To produce a slide series with text and sound which shows methods for land preparation, planting, harvesting, etc., of energy plantations. Also a small information folder shall be produced.
PROGRESS: Since facts about energy plantations and useful handling methods are changing, the information set will have to be updated, very likely once a year.
INTENDED USE OF RESULTS: The material shall be used in campaigns to interested parties in Sweden.
SUPPORTED BY Namnden for Energiproduktionforskning

2.0315,
BIOCONVERSION POSSIBILITIES
R. Schuster, Fjarrvarme Ab, *S-150 13, Trosa, Sweden*
OBJECTIVE: Mapping of Bioconversion possibilities today and in the future.
APPROACH: Literature studies and personal visits domestic and abroad.
INTENDED USE OF RESULTS: The work is the first separate stage in later on more thorough investigation, of different bioconversion methods and their potential for Sweden supported by the agency.
SUPPORTED BY Namnden for Energiproduktionforskning

2.0316,
METHANE FERMENTATION OF INDUSTRIAL WASTE
P. Ronnow, Goteborgs Universitet, Marine Microbiology, *411 Vasaparken, S40010 Goteborg, Sweden*
OBJECTIVE: To give a microbiological and biochemical description of the way anaerobic bacteria are responsible for the breakdown of organic matter and the formation of methane. The investigation aims to acquire knowledge as to how such bacteria populations adjust to and influence each other under different environmental conditions. The acquired knowledge will enable us to set up a detailed kinetic model

for partial reactions as well as for an overall reaction of the formation of methane from organic matter.
APPROACH: Enrichment and isolation of bacteria capable of thermophilic hydrolysis of penicillium mycelium (used as a model substrate) and of thermophilic methanogenesis. A subsequent study of the breakdown pattern, with and without population of methanogenic bacteria. Furthermore, a study on the variations in population sizes and their influence on the activity and growth of the different bacterial groups.
PROGRESS: At present, work is centered on the enrichment and isolation of anaerobic bacteria which hydrolyze penicillium mycelium and bacteria producing methane.
INTENDED USE OF RESULTS: The result of this project will be used to develop an anaerobic digester which will be optimized for the production of methane.
SUPPORTED BY Styrelsen for Teknisk Utveckling

2.0317,
DEVELOPING ACTIVE TOOLS FOR BUNDLE TWIGING

E. Karlsson, Hydrovag Ab, *Abyn 1208, S93020 Burtrask, Sweden*
OBJECTIVE: Study of capacity and quality with different active tools for removal of twigs from small trees in a bundle.
APPROACH: The project is a part of Skellefteaterminalen (NE 3065 311). By practical tests in a test rig, the different active tools will be evaluated.
INTENDED USE OF RESULTS: The results will be used by forest companies to take care of small trees from thinning and for use of the wood as industrial wood and fuel wood.
SUPPORTED BY Namnden for Energiproduktionforskning

2.0318,
FUELS BASED ON SOLID STATE/LIQUID MIXTURES

E. Haeffner, Institut for Innovationsteknik, *Drottning Kristinas Vag 48, S11428 Stockholm, Sweden*
OBJECTIVE: This project is concerned with the development of a process for the production of a fuel consisting of a suspension of a solid substance with high energy content e.g., peat, pulverized wood, bark, coal, or mixtures of these, in a combustible fuel e.g., methyl and/or ethyl alcohol.
This type of suspension has advantages in providing a mixture with higher energy content per volume compared with the pure liquid and in allowing the use of conventional technology regarding transportation, storage and combustion.
APPROACH: By dispersing e.g., pulverized coal in methanol to which special surface-active agents and/or thickening agents have been added, a stable suspension is obtained. This makes a fuel whose energy content is in the region of 75% of that of fuel oil.
The development work is aimed at optimizing, by tests, the composition of the fuel mixtures described above and at analyzing the combustion properties. In this context, it is also planned to study additives in order to eliminate SO2 and SO3 and also in order to facilitate the supply of oxygen to the combustion process.
INTENDED USE OF RESULTS: Owing to the comparatively high energy content, this fuel might be used in the replacement of fuel oil for heating single-family houses and in district heating plants.
SUPPORTED BY Styrelsen for Teknisk Utveckling

2.0319,
ENERGY RECOVERY FROM MANURE

O. Ohmark, Jarvso Verken Ab, *S82040 Jarvso, Sweden*
The aim of the project is to find out whether it is economically justified to recover energy from manure, both for the operation of the electric equipment of a farm, and for satisfying the heat requirements of dwelling-houses and other buildings belonging to it.
The environmental advantages of such a procedure (no air pollution), as well as its importance in times of emergency make it an issue which must not be neglected.
The properties of fully digested manure, such as less odour, faster nitrogen effect, and easier pumping, may result in less demand for commercial manure, which would have a favourable effect on economy. Distribution may be done in a more sensible way than before, which may prevent water pollution.
SUPPORTED BY Styrelsen for Teknisk Utveckling

2.0320,
TECHNOLOGY AND COSTS FOR COLLECTION OF HOUSEHOLD WASTE AS FEEDSTOCK FOR METHANOL PRODUCTION

A. Brandberg, K Konsult, *Liljeholstorget 7, S11780 Stockholm, Sweden*
OBJECTIVE: Study of technology and costs for collection household waste as feedstock for methanol in comparison to present disposing systems.
APPROACH: As use of waste as feedstock larger quantities have to be concentrated to one place. The technical set up for such a transportation system will be studied based on known technology. Future changes of quantities and composition will be discussed. Transport and handling costs for the systems considered will be calculated and compared with those of existing systems (landfill and incineration).
INTENDED USE OF RESULTS: To assist in judging whether use of waste as feedstock for methanol is an attractive feedstock or not and to determine optimal sizes.
SUPPORTED BY Namnden for Energiproduktionforskning

2.0321,
SYSTEM FOR HARVEST, TRANSPORT, DRYING AND QUALITY SEPARATION OF WHOLE-GRAIN, GREEN-CROP ETC.

I. Bjurenvall, Kockums Construction Ab, *Box 14, S26301 Hoganas, Sweden*
OBJECTIVE: To obtain high-quality agricultural products for different purposes, e.g., energy raw material.
APPROACH: The project is carried out through a full-scale prototype plant. The project is divided into 11 different part projects in order to solve every part target as effectively as possible. This project is a proceeding of a development made within the company in a pilot plant. The results of the crop during 1977 show good possibilities to develop a system as above. The project now started-up has as target to optimize the different project parts and to get a total optimization of the whole system.
INTENDED USE OF RESULTS: The project is an agricultural project which shall be run within the agricultural limits. The intention is that considerably more energy and protein than today will be produced from the agricultural area through this project. The results of the project can be put into practice through primarily replacement of the oil need by the biomass produced.
SUPPORTED BY Namnden for Energiproduktionforskning

2.0322,
INCINERATOR FOR SOLID FUELS WITH VARIABLE HEAT VALUE AND HIGH MOISTURE CONTENT

A. Haag, Kockums Energisystem Ab, *Fack S-201 10, Malmo, Sweden*
OBJECTIVE: Many cities and municipalities in Sweden are situated in areas where a relative large amount of so called waste solid fuels, like wood wastes, coals, shales, straw, domestic wastes, etc. are available. This project is supposed to basically investigate the problems of fuel handling, transport, incineration control and ash handling connected to a incinerator for those fuels.
APPROACH: The project is based upon the 'Fluidized Bed Combustor' techniques and is separated in two parts.
The first part will include all necessary investigation as well as the construction work for a 10 MWth prototype incinerator connected to heat water boiler.
The second part, which will be carried out later on, will include manufacture and erection of the prototype incinerator and a test period for different types of solid fuels.
The investigation and construction work will basically be concentrated upon the problems named above.
INTENDED USE OF RESULTS: Assuming that the project work is successful in all parts, it will be possible to present practical results in the beginning of 1980. These results will lead to a construction of a 25 MWth full scale incinerator for district heating purposes which then will be available in the Swedish market about two years later. Within the range of five to six years from now, the project will then contribute to the nation's energy resources to an estimated amount of about ten percent.
SUPPORTED BY Namnden for Energiproduktionforskning

2.0323,
PRODUCING OIL FROM WET PEAT BY HIGH PRESSURE TREATMENT USING HYDROGEN GAS AND/OR CARBON MONOXIDE

P. Bjornbom, Kungliga Tekniske Hogskolan, Chemical Technology, *S10044 Stockholm 70, Sweden*
OBJECTIVE: To study different systems of high pressure treatment of wet peat for the production of oil using hydrogen gas and/or carbon monoxide, combined with separation of the water in the peat. Also biomass is included.
APPROACH: Exploratory research, mainly experimental, aiming to synthesis and analysis of different process concepts for oil production from peat/biomass.
Stage 1 of the project (research project no 53 3062 021) included preliminary technical economic evaluation, state 2 and 3(No 53 3062 022 and 53 3062 023) include experimental work. Stage 2 was carried out in Canada in cooperation with Prof. Chornet at the University of Sherbrooke, Ouebec, Canada.
PROGRESS: Results were presented in reports dated March 29, 1976 and January 24, 1977.
In stage 3 (the current phase of the project), the experimental work will be continued at the Royal Institute of Technology in Stockholm.
SUPPORTED BY Namnden for Energiproduktionforskning

2.0324,
ENERGY CONSERVATION EQUIPMENT FOR HEATING ONE FAMILY HOUSES

H. Brosenius, Kungliga Tekniske Hogskolan, Building Technology, *S10044 Stockholm 70, Sweden*
This project refers to the continued processing and development of energy conservation equipment for heating one family houses.
The project constitutes a main project with five subprojects. As a rule, the subprojects are based on invention ideas for which patents have been sought. The main project is an accumulator system in each one family house which can be expected to make increased efficiency possible in oil fired, wood fired, etc. systems through a new and completely automatic device.
Another processed accumulator system is based on the principle that the cost of the expensive heat generating plant (oil fired plant, heat pump) is divided amongst several one family houses by means of a new heat balance system.
The project also embraces two more secondary research projects and one project concerning energy cost studies.
SUPPORTED BY Statens Rad for Byggnadsforskning

2.0325,
ASSESSMENT OF DEVELOPMENT POTENTIAL OF SMALL GASIFIERS FOR LOW KJ GAS

R. Collin, Kungliga Tekniske Hogskolan, Heat & Furnace Technology, *S10044 Stockholm 70, Sweden*
OBJECTIVE: A large proportion of Sweden's oil consumption could be substituted by alternative fuels such as coal, peat, wood waste, bark, shale and so on. Many existant furnaces and boilers, however, are built for the exclusive use of liquid or gaseous fuels. A more rapid conversion would be possible if such plants could be supplied with a generator for a low KJ-gas. The generator would have lower capacity, small dimensions and would possibly be so cheap that even small plants could be equipped with it. The present preliminary study aims at a detailed plan for an R & D project, leading to a gas generator, which must fulfil the following criteria: Must accept fuels of varying quality and heat value. The mean efficiency must be acceptable. The emission of polluting agents must be lower than stipulated by present and future regulations. It must be equipped with advanced control equipment. The equipment for supply of fuel and disposal of slag must have small dimensions.
APPROACH: The study contains the following parts: Assessment of existing technology by literature studies and study trips. Continued experiments with different fuel qualities in an existing fluidized bed fur-

nace. Contacts and discussions with research teams in Sweden and abroad in order to assess the possibilties to collaboration.

PROGRESS: The experiments in the previous step, NE 3066062, has shown that combustion with high efficiency and low excess air ratio is possible in a small reactor, diameter 350 mm.

INTENDED USE OF RESULTS: The R&D plan will be used by the research team itself. The experiment results will be published. If the R&D plan is accepted, the result of the development may have an impact on Swedens's use of energy in 7 to 10 years.

SUPPORTED BY Namnden for Energiproduktionforskning

2.0326,

COAL GASIFICATION AND SMELTING REDUCTION BY THE INJECTION OF COAL, OXYGEN AND ORE CONCENTRATE IN A HOT METAL BATH

S. Eketorp, Kungliga Tekniske Hogskolan, Ferrous Metallurgy, *S10044 Stockholm 70, Sweden*

OBJECTIVE: To develop a new reduction and coal gasification process, in which sulfurous coal and ore powder may be used directly, without cooking. Preliminary results must be confirmed by more comprehensive studies of parameters, and awareness of the process mechanism heightened.

APPROACH: Laboratory tests, possibly followed up by large-scale tests for the purpose of investigating various parameters regarding reduction and gasification. Co-ordination of this project and the projects 77-4287 and 77-4286 will be required.

PROGRESS: The results of earlier tests are very promising.

INTENDED USE OF RESULTS: If this method proves to be a success, it could mean that there is scope for the direct use of phosphorous ore concentrate and that low-grade coal may be utilized. Besides reducing the energy consumption of iron production, it may also affect the energy structure in favor of pit coal and, possibly, wood chips from biowoods.

SUPPORTED BY Styrelsen for Teknisk Utveckling

2.0327,

ASSESSMENT OF ALTERNATIVE PATHS FOR TRANSFORMATION BIOMASS TO USEFUL ENERGY

O. Lindstrom, Kungliga Tekniske Hogskolan, Chemical Technology, *S10044 Stockholm 70, Sweden*

No summary has been provided to the Smithsonian Science Information Exchange.

SUPPORTED BY Namnden for Energiproduktionforskning

2.0328,

ASSESSMENT OF ALTERNATIVE PATHS FOR TRANSFORMATION BIOMASS TO USEFUL ENERGY

O. Lindstrom, Kungliga Tekniske Hogskolan, Chemical Technology, *S10044 Stockholm 70, Sweden*

OBJECTIVE: The project is a pre-project study of the technical and economic aspects of domestic fuel production based on biomass and peat. Scenarios will be set up and one will be selected, where in the long run Sweden will be made independent of nuclear power and oil, the energy production being based solely on renewable sources, mainly biomass and hydroelectric power, with contributions from wind, solar energy etc.

APPROACH: The emphasis is laid on conversion, comprehensive system analysis and system optimization, where methodics will be of special interest. The project is part of the Board for Energy Source Development's program for Biosystems. Progress reports will be issued in Nov. 1977 and in Feb. 1978.

INTENDED USE OF RESULTS: The report will among other things help in political decisions concerning Sweden's energy policy. It will give an understanding of the biomass alternative and its consequences.

SUPPORTED BY Namnden for Energiproduktionforskning

2.0329,

STUDIES ON GASIFICATION OF PEAT AND BIOMASS, LIQUEFACTION OF PEAT AND DEWATERING OF PEAT

O. Lindstrom, Kungliga Tekniske Hogskolan, Chemical Technology, *S10044 Stockholm 70, Sweden*

OBJECTIVE: Continued studies on gasification of peat and biomass, liquefaction of peat and dewatering of peat. These studies were earlier divided in three different projects (NE 3066 012, NE 3062 022 and 3062 031 respectively). Beside these main activities other activities within the energy research sector should be carried out. The future role of the Department of Chemical Technology within the research program of the Board of Energy Source Development should be defined.

APPROACH: Basic chemical and kinetic data are gathered by use of small scale laboratory equipment. Different processes within gasification, liquefaction and dewatering technology are evaluated with respect to the specific Swedish conditions.

PROGRESS: In all these fields of fuel technology (gasification, liquefaction and dewatering), literature studies have reviewed the existing technology. Small scale laboratory studies have indicated the special characteristics of peat and biomass and possibilities for conversion processes. The research work is concluded.

INTENDED USE OF RESULTS: In order to utilize the potentially very big resources of peat and biomass for energy production, it is necessary to develop conversion methods which can give energy carriers such as methanol, methane, hydrogen or fuel oil. The necessary research program for that is indicated and suitable future research projects can be identified.

SUPPORTED BY Namnden for Energiproduktionforskning

2.0330,

DEVELOPMENT OF AN OXYGEN-FREE GASIFICATION PROCESS FOR PEAT AND BIOMASS - REACTING TO A MEDIUM BTU-GAS

E. Rensfelt, Kungliga Tekniske Hogskolan, Chemical Technology, *S10044 Stockholm 70, Sweden*

OBJECTIVE: Development of a oxygen-free gasification process which gives a medium BTU-gas. Fuels of interest are peat and biomass. The goal for the present step is to specify a PDU (Process Development Unit).

APPROACH: Basic Kinetic and Chemical data are gathered through experiments in existing LRU's (Laboratory Research Unit). These consist of a continous unit for flash-pyrolysis and two batch reactors for studying pyrolysis and gasification at normal pressure.

A continuous Laboratory Development Unit will be constructed and experiments concerning both pyrolysis and gasification conducted at elevated pressure. The development of gasification processes abroad is followed and processes of special Swedish interest are carefully examined.

Fuels (salix and populus) produced within the biomass project 53 3065 012 (G Siren) are studied. This is the 3rd stage of the project (stages 1-2 have the project number 53 3066 012).

PROGRESS: Our studies have shown that the pyrolysis of pulverized peat and wood are very fast. The rate determining step in total gasification is the gasification of char-peat and biomass are very reactive (with steam) compared to coal. Thus the temperature in the gasification reactor can be kept comparatively low (750-900 degrees C). The heat necessary for gasification can be transmitted to the reactor by a heat exchanger placed directly in the bed. The experiments are planned to be made in a pressurized fluidized bed.

INTENDED USE OF RESULTS: In order to utilize the potentially very large resources of peat and biomass for energy production, it is necessary to develop conversion methods which can produce energy carriers such as methanol, methane or hydrogen. A very important step in this process is the gasification to a medium BTU-gas. The common processes for that purpose utilize oxygen. Due to the high cost of oxygen, especially in small plants, it is very important to develop oxygen-free processes.

SUPPORTED BY Namnden for Energiproduktionforskning

2.0331,

INVESTIGATION ABOUT PEAT FIRING AT LUNDS KRAFTVARMEVERK AB DISTRICT HEATING HOT WATER BOILER PLANT IN THE CITY OF LUND

A.G. Olausson, Lunds Kraftvarmeverk Ab, Heat Power, *Malmo, Sweden*

OBJECTIVE: Investigation and pre-projecting including preliminary calculation of investment costs for a peat/oil-fired 75 MWv hot water boiler to be installed at the district heating center in the city of Lund as a alternative to an only oil-fired boiler.

APPROACH: The consequences of installing a 75 MWv peat/oil-fired hot water boiler instead of only an oil-fired boiler shall be clarified with regard to the local conditions and available space for boiler, need for stock of fuel and fuel handling equipment.

For this, tenders of the boiler and associated equipment will be requested and evaluated. The preliminary investment costs for a boiler plant laid out for peat and oil firing will be calculated. In connection to that, it will be necessary to work out a preliminary layout and to estimate the environmental and transport consequencies.

An analogous investigation will be made by Angpanneforeningen (The Steam Users Association) at the request of OEF (The National Swedish Board for Economic Defense) for a peat-fired boiler plant in the cities of Boden and Vaxjo respectively but with boilers with lower capacities.

INTENDED USE OF RESULTS: The results of this investigation can be used by communities with district heating in operation or in planning when investigating new boiler capacity in the future and comparing peat firing with oil, coal or wood firing.

SUPPORTED BY Namnden for Energiproduktionforskning

2.0332,

RELATIONSHIP BETWEEN CELL-MASS PRODUCTION AND PRODUCT FORMATION IN ANAEROBIC SYSTEMS

N. Molin, Lunds Universitet, Chemical Center, Technical Microbiology, *Box 740, S22007 Lund 7, Sweden*

The object of the project is to define the relationship between product formation and cell-mass production in anaerobic systems. The production of metabolites is dependent on the amount of cell mass available and its physiological condition.

In a first phase, work will aim at defining cultivation conditions which give optimal cell growth. Thus, the importance of the following parameters will be studied: 1) graft material, 2) spore formation, 3) the redox potential, 4) medium composition, 5) the composition of the gaseous phase. Moreover, alternative methods for cell-mass production and product formation are to be tested out.

SUPPORTED BY Styrelsen for Teknisk Utveckling

2.0333,

ENERGY REEDS

S. Bjork, Lunds Universitet, Inst. of Limnology, *S22003 Lund 7, Sweden*

OBJECTIVE: To investigate the possibilities - ecological and technical - of using the common reed (Phragmites australis) as a source of energy.

APPROACH: The project is divided into 5 parts, the first starting in 1977. The current part (no 2) is devoted to greenhouse and small scale outdoor experiments on planting and fertilization of reeds, determination of biomass and chemical content of reeds from various parts of Sweden, initiation of a further technical development of existing reed cutting machines and full scale reed cutting experiments. The project is connected to NE 3065 041 Powder.

PROGRESS: Results of part 1 has been reported: Energivass (CODEN: LUNBDS/(NBLI-3001)/1-77 (1978). Use of common reed for cellulose production in Romania, thatching and reed mat fabrication in Austria, wastewater treatment in the Netherlands and research experience on the common reed in Sweden and elsewhere is dealt with in the report. Also the possibilities of using the common reed for energy purposes in Sweden are discussed. Items included in the report are: ecology of the reed, areas and productivity of reed in Sweden, reed-harvesting, cultivation of reed, energy balance for reed cultivation and energy potential for Sweden. Part no 2 of the energy reed project aims to show the possibilities of harvesting reed in winter, transforming the reed stems to a fuel (e.g. grinding), planting of reed

and production increases through the application of fertilizers.
INTENDED USE OF RESULTS: Reeds can be used as a local source of energy in Sweden, probably after 1985.
SUPPORTED BY Namnden for Energiproduktionforskning

2.0334,

FIRING TESTS WITH INLAND SOLID FUEL IN OSBY VRT-BOILER AND ANALYSIS OF THE ECONOMIC ASSUMPTIONS FOR REGULAR DISTRICT HEATING

F. Ek, Osby Varme Ab, *S-283 00, Osby, Sweden*
OBJECTIVE: Select the basic documents to consider the quality of the present A-boiler type and the potential need of a modification by fitting with wood chips and peat. Give an account of the technical and economical possibilities to function in a district heating plant and in case of a crisis with these fuels. Take potential steps to enable the measuring of NOx and PAH during the stage.
APPROACH: Stage 1. Detail planning. Application regarding permission to use a test place. The purchase of fuel and transports. Preparations for the test on the place. Test no. 1. - Completion of test no. 1 and preparations for test no. 2. Test no. 2 - Completion and restoration of the plant including masonry etc. Valuation and report of the measurements. Economic analysis, regular firing with solid fuel. Final report.
Stage 2. Test of the fuel feeding device and the firing automatics. Eventual continued fuel tests. Proposed demonstration plant. Time and costs for the second stage are unknown.
PROGRESS: New project.
INTENDED USE OF RESULTS: From the view of preparedness it is important to have a good knowledge about how oil-fired boilers, in reasonable time and with a minor loss of capacity, can be converted for firing with inland solid fuel. The investigation is important with regard to a conversion permanently to other fuels than oil that might be necessary within the next decades. The investigation of the economic conditions of regular district heating production with inland solid fuel shall illustrate the facts which have to be regarded when working out plant of this kind and indicate the economic potential when a more extensive use of inland fuel for centralized heat production is in question.
SUPPORTED BY Namnden for Energiproduktionforskning

2.0335,

UTILIZATION OF THE WHOLE TREE (ENERGY PRODUCTION)

P. Alsefelt, Projekt Heltradsutnyttjande, *Villagatan 1, S11432 Stockholm, Sweden*
OBJECTIVE: The project aims at providing a basis of and developing methods for technical utilization of that assortment of wood raw material which, with present conventional felling methods, is left in the forests or separated within industry and regarded as waste. Marginal raw material considered are tops, branches, stumps and roots as well as smallwood which remain after cleaning and thinning a forest.
APPROACH: The project work is to be assigned to four project groups or subject sectors: forest, logging, pulp, and fibreboard/ particle board.
PROGRESS: The project is in progress and a final report is to be expected at the end of 1977.
INTENDED USE OF RESULTS: Better utilization of wood raw material.
ADDENDA: Performing organization: Projekt Heltradsutnyttjande.
SUPPORTED BY Styrelsen for Teknisk Utveckling

2.0336,

INVENTORY AND INVESTIGATION OF THE PREMISES OF THE EXPLOITATION OF ORGANIC FUELS IN THE COUNTY OF VASTERVOTTEN

H.B. Parson, Regional Development Fund, *Domarevagen 5, S90252, Umea, Sweden*
OBJECTIVE: Survey of available organic fuels in the county of Vasterbotten.
APPROACH: An overall study concerning the supply of organic fuels (peat, wood, waste, bark, garbage, etc). This first stage will mainly be performed as an internal research, based on maps, photos, earlier investigations. In the next stage more profound studies will be carried on in limited geographic areas.
INTENDED USE OF RESULTS: The results may be used by communities and other big producers in their planning of fuel acquisition, heat and power production and distribution.
SUPPORTED BY Namnden for Energiproduktionforskning

2.0337,

EXPERIMENTS AND STUDIES CONCERNING THE CULTIVATION OF FAST-GROWING CLONES SUCH AS POPLAR AND SALLOW SUITABLE FOR ENERGY PRODUCTION

G. Siren, Royal College of Forestry, Reforestration, *S10405 Stockholm, Sweden*
OBJECTIVE: Experiments and studies will be made concerning the intensive cultivation of fast-growing types of trees which, after a certain initial period, will produce 2-4 kg dry trunk wood per sq. m during one growth cycle. The heat content of the wood is approximately equivalent to 1-2 kg oil. The rate of growth is also to be studied where the soil is heated by waste heat from nuclear power stations.
The current phase of the project is stage 3.
APPROACH: In stage 1 of the project (research project No. 53 3065 011), the program of experiments was structured and a plant research station at Studsvik, Sweden has been laid out.
PROGRESS: In stage 2 of the project, the cultivation experiments are carried out. Samples for analysis are taken and the growth and production are studied. If the results come up to the expectations, preparations are to be made for the construction of a computer system, the expansion of experiments on mineralogenic and organogenic substrata and studies of the soil heating experiments.
The results are to be presented by 1977-01-15 at the latest.
The research work will be extended by this third stage during 1977-1982.
A part of the project is planned to be internationalized within the framework of the IEA collaboration.
SUPPORTED BY Namnden for Energiproduktionforskning

2.0338,

EXPERIMENTS AND STUDIES CONCERNING THE CULTIVATION OF FAST-GROWING CLONES SUCH AS POPLAR AND SALLOW SUITABLE FOR ENERGY PRODUCTION

G. Siren, Royal College of Forestry, Inst. of Reforestration, *S10405 Stockholm, Sweden*
OBJECTIVE: To reduce dependence of imported energy by the introduction of a highly mechanized production system for fast-growing deciduous species ecologically suitable for available land (swamps and abandoned arable land).
APPROACH: The following subprojects are operational:
Selection of clones based on genetic characters, efficiency of photosynthesis and nutrient uptake, wood anatomy and production-ecological response.
Cutting production; optimization of the production of selected clones; dependence of output on various combinations of soil physics and chemistry as well as climate is checked with appropriate production models; studies and control of unwanted environmental effects.
Development of production systems; production reducing diseases, insect plagues and methods of combating them; Studies of energy balance; Studies of profitability; establishment of full-scale stands for harvesting techniques studies; inventory of ecologically acceptable and operationally accessible areas for energy forestry.
PROGRESS: Some 40 Salix-clones and less than 10 Populus-clones (less than 5 percent) remain after selection based on growth, rooting, shooting, resistance, hardiness, wood density etc.
A few clones have produced in semi-controlled open air conditions (fertilization plus irrigation) about 10 to per hectare per year.
RESULTS: Accepted clones will contribute to the basic material for full-scale energy-forestry. The optimization results will be used in instructions to the future energy producers. Regional planning of energy production will require the results of area inventory.
SUPPORTED BY Namnden for Energiproduktionforskning

2.0339,

FUEL COMBINATION

M. Engstrom, Sala Innovation Ab, *Storgatan 13, S15200 Strangnas, Sweden*
OBJECTIVE: Mapping the technique of manufacturing, handling and use of fuel mixtures consisting of coal plus oil, peat plus oil, shale plus oil and biomass plus oil.
APPROACH: The work will start with a large information search and analyses, followed by complementary activities.
INTENDED USE OF RESULTS: The use of fuel mixtures as above will lead to raw material flexibility and less oil dependence.
The result of the stage will be the basis for estimating the possibility of using the fuel mixtures and the need of continued activities in a following stage.
SUPPORTED BY Namnden for Energiproduktionforskning

2.0340,

MACHINES FOR HARVESTING AND TRANSPORTATION OF WOOD BIOMASS

L. Magnusson, Sikob Ab, Energy, *S19178 Sollentuna, Sweden*
OBJECTIVE: A preliminary identification of requirements on machines for harvesting wood biomass from silvi-cultural biomass farms and a survey of alternative machine systems.
APPROACH: The project will include: - a preliminary study to define requirements set by characteristics of suitable land, ecology, actual wood species as well as requirements from potential users of biomass energy products. This work will be based on knowledge from parallel projects on wood biomass supported by the National Swedish Board for Energy Source Development. - a survey of alternative machine systems for harvesting and transportation of wood biomass, and a technical and economic evaluation of these. Energy consumption of these systems will also be estimated.
The study does not include forest residues, which is covered in project No 53 3065 091. (Skogshogskolan the Royal College of Forestry.)
INTENDED USE OF RESULTS: As a basis for further studies and for possible future development of a prototype harvesting equipment.
SUPPORTED BY Namnden for Energiproduktionforskning

2.0341,

SKELLEFTEA-TERMINAL (WOOD TERMINAL OF SKELLEFTEA)

C. Bredberg, Skelleftea Municipality, *S93101 Skelleftea, Sweden*
OBJECTIVE: Analysis of technical and economical conditions for a terminal within the Skelleftea region for preparation of slash into industrial raw material and fuel.
APPROACH: Studies within the project: a) Suitable feed area and supply of low-grade timber, etc. Stocktaking of experimental area. b) Machines, methods and costs for expelling and forwarding by forestry thinnings. Experimental cutting with different mechanical methods. c) Position of the terminal station, functions and machinery equipment. d) Need of further technical development of the components of the terminal system. e) Receivers and transports. f) Profitability analysis. g) Proposal for organization and design of concrete terminal establishment.
PROGRESS: The project intends to find out to what extent low-grade timber and slash can be used as industrial raw material and under what conditions this use can be profitable, when using the above methods.
SUPPORTED BY Namnden for Energiproduktionforskning

2.0342,

BROAD-LEAVED TREES IN ROUNDWOOD OR WOOD CHIPS AS FUEL WOOD IN FARM HOUSES

M. Bendz, Sodra Skogsagarna, Forestry Division, *S35189, Vaxjo, Sweden*
OBJECTIVE: The practical coordination and organizing of supply of fuel wood to farm houses within a Forest Owners Association. The foundation of technically and economically suitable solutions in practically operating systems. The organizing of woodlot owners in production of wood residues for heating.

APPROACH: By using existing resources and organization of a forest owners association create interest and demand for technique and know-how to use wood for heating. Subsidizing certain parts of equipment. Subsidizing wood costs in introductory stages. Association of producers of equipment and technical know-how to project. Evaluation of both complete systems and separate operations.
INTENDED USE OF RESULTS: To create interest and self-propelling activities to use wood in the production of energy. To increase use of wood-waste and non-commercial trees. To find suitable technical arrangements in order to help initiate and expand activities in the field of 'wood heating'. Primarily in private houses but also in larger or medium-sized houses/plants it is expected to find permanent uses.
SUPPORTED BY Namnden for Energiproduktionforskning

2.0343,
DEVELOPMENT OF CHIP DRYING KILNS

E. Sondell, Sondells Fabriks Ab, *Fack 100, S-890 51, Langviksmon, Sweden*

No summary has been provided to the Smithsonian Science Information Exchange.
SUPPORTED BY Styrelsen for Teknisk Utveckling

2.0344,
EXECUTION OF THE ANALYSIS, PLANNING AND MANAGEMENT OF THE WORK FOR METHANOL PRODUCTION STUDIES

A. Brandberg, Svenska Metanolutveckling Ab, *Banergatan 10, S11522 Stockholm, Sweden*

OBJECTIVE: Investigations on the presumptions for production of methanol from various feedstocks. Survey of future market for methanol.
APPROACH: Studies of published literature and participation in multiclient studies with consulting firms. Evaluation of information collected to form long-range plans and further more detailed investigations in special projects. Administration and evaluation of such projects.
PROGRESS: Future strong growth in demand of methanol by the chemical industry is indicated also for Sweden. New market might be for production of protein by fermentation and towards the end of the 80's for motor fuel in blends with gasoline. The impact of methanol on the refinering is studied. Natural gas from northern North Sea is of particular interest to Scandinavia as feedstock along with residual oils. Domestic feedstocks available in sufficient quantities are the fossil peat and shale. The residues from the forest industry are a potential renewable feedstock as direct farming of biomass might be. Various routes to synthetic fuels will be studied for comparison. More detailed evaluation for the most promising routes will be accomplished as special projects.
USE OF RESULTS: To form a basis for future energy policy decision particularly concerning future supply of motor fuels in normal and emergency situations.
ADDENDA: Performing organization: Svenska Metanolutveckling AB.
SUPPORTED BY Namnden for Energiproduktionforskning

2.0345,
FUTURE FUEL MARKETS IN SWEDEN

H. Ljung, Svenska Utvecklings Ab, *Box 210 48, S10031 Stockholm, Sweden*

OBJECTIVE: The aim of the investigation is to find out to what extent it will be technically and economically possible to substitute domestic fuels in Sweden around the years 1990 and 2000 respectively, under certain given conditions. An estimate will also be made of the maximum technical potential for each type of fuel as well as a realistic estimate of possible market shares at those points of time.
The investigation will mainly study the possibilities for substitution fuels and examine to what extent there is a market in Sweden for new fuels intended to replace fuels now in commercial use -particular different kinds of oil products.
APPROACH: A market investigation will be made for each new type of fuel and whenever possible a general survey will be made of process sensitivity for different uses. The results obtained will give certain indications as to the prerequisites for introducing new types of fuel.
The emphasis of the investigation is on the demand side of fuel market, i.e., the study of technical, economic and other prerequisites for introducing new types of fuel on the market.
Detail of production and distribution costs for new types of fuel, which are necessary to enable an estimate of market prices, are based on information obtained in other contexts.
The investigation will primarily take the following energy raw materials into account: peat; biomass, firewood from energy forests and timber-cutting waste; other organic waste; coal.
Natural gas will also be taken into account. Shale will not be considered in the study, or possibly only to a very small extent.
SUPPORTED BY Namnden for Energiproduktionforskning

2.0346,
EVALUATION OF THE KOPPELMAN PROCESS

L. Ojefors, Svenska Utvecklings Ab, Energy & Environ Tech, *Box 210 48, S10031 Stockholm, Sweden*

OBJECTIVE: To evaluate the Koppelman process for accurating of peat, wood, etc.
APPROACH: Since the Koppelmen process for peat and wood is in a comparatively early stage of development it is necessary first to evaluate its function in present pilot scale. Not until such an evaluation has given positive results is it meaningful to continue the evaluation activities. Consequently the activities have been divided into two phases.
PROGRESS: During phase 1, the inventor will be visited at Stanford Research Institute, Menlo Park, where the present status of his development activities will be reviewed and the following questions clarifed: the process' function in present pilot scale for different fuels, the possibility to scale up the process, remaining development work, economics of the process in full scale.
If the results of phase 1 are promising, the evaluation will proceed in phase 2 by a further in depth investigation of the technology by specialists and an economic evaluation of using this process both in pilot scale and later on in our future energy system.
INTENDED USE OF RESULTS: The result of the project will be used by the Swedish Board for Energy Source Development in its evaluation of methods to accurate fuels.
SUPPORTED BY Namnden for Energiproduktionforskning

2.0347,
PREPARATIONS FOR INTERNATIONAL COOPERATION CONCERNING ENERGY RESEARCH WITHIN FOREST INDUSTRY UNDER IEA'S MANAGEMENT

I. Jullander, Swedish Forest Products Research Lab., *Box 5604, S11486 Stockholm, Sweden*

OBJECTIVE: Under IEA's management to bring about international cooperation concerning energy research within the forest industry field.
APPROACH: Contacts with European organizations relevant to the above task.
PROGRESS: The project work will be initiated May 23, 1977.
INTENDED USE OF RESULTS: The results of this project work will form the basis of further negotiations on cooperation agreements under IEA's management.
SUPPORTED BY Styrelsen for Teknisk Utveckling

2.0348,
BARK PRESSING

I. Sandqvist, Swedish Forest Products Research Lab., Wood Products, *Box 5604, S11486 Stockholm, Sweden*

Swedish forest industries handle large bark quantities, roughly 2 million tons of dry weight/year. The major part of this bark is burnt. The energy yield highly depends on its dry matter content. A 5% increase of dry matter content at a 40% dry matter content will enhance heat yield by 8-12%, which, in Sweden, would mean saving 100,000 cubic meters of fuel oil/year.
The least expensive way to remove water from wet bark is pressing, a method which yields today roughly 40% dry matter content.
This investigation is expected to lead to a development of better bark pressing equipment, which a) is of great economic importance to forest industry; b) would contribute to the general energy supply; c) would help to find a good solution of environmental problems connected with bark pressing; d) would provide a basis for manufacturing and export of Swedish engineering products.
PROJECT PLAN: 1) Literature studies and tests centered on the moisture sorption capacity of bark. 2) Evaluation of what bark assortment should be the subject of continued investigation. 3) Determination of the proportion of water in bark, which is bound, free, and 'on the outside'. 4) Pressing tests in a laboratory press. 5) Possible fields tests, and 6) Possible tests of surveying character, with other solutions, for example hydroextraction.
SUPPORTED BY Styrelsen for Teknisk Utveckling

2.0349,
INVESTIGATION CONCERNING PRODUCTION OF METHANE GAS OUT OF MANURE AND OTHER WASTE PRODUCTS

O. Noren, Swedish Inst. of Agricultural Engineering, *Ultuna, S75007 Uppsala 7, Sweden*

Before initiating an extensive development project concerning the production of methane gas out of manure and other waste products, a preliminary investigation will be made. This investigation will result in a project plan for a Swedish methane-gas project.
Since process time and gas yield are important factors as regards economy, the aim is to find out how much is known, in different parts of the world, about the microbiology of methane gas reaction, within the field concerned. Furthermore, the most suitable application of the gas will be studied, i.e., application for heating purposes, production of electric power or internal combustion-engine drive. The storage problem will also be investigated. A draft design for inexpensive storage of gas, and possibly also a screening test, should be inclued in this part of the investigation.
The investigations mentioned above will serve as the basis for a draft design for a methane reactor. An estimate of investment requirements as well as costs of methane gas production will then be made.
SUPPORTED BY Styrelsen for Teknisk Utveckling

2.0350,
A SWEDISH METHANE GAS PROJECT - INCLUDING THREE SUB-PROJECTS

O. Noren, Swedish Inst. of Agricultural Engineering, *Ultuna, S75007 Uppsala 7, Sweden*

OBJECTIVE: To clarify questions such as how much digester gas is generated and what is the methane content of different kinds of rotting manure, other organic material and various plant materials. Furthermore, a detailed analysis will be made of single-stage as well as two-stage rotting.
APPROACH: Laboratory experiments will be carried out in order to determine the limit values of different parameters and study different problems associated with full-scale tests. Suitable process techniques for energy recovery and energy utilization as well as anaerobic treatment of offals will be studied in full-scale tests. The experience gained from laboratory experiments and full-scale tests will be used in application tests to be carried out on cattle on a farm, in order to calculate economic and functional factors.
PROGRESS: Certain laboratory experiments have been completed and reported. A systematic calculation of costs has been made for farm units of different sizes.
INTENDED USE OF RESULTS: This project will result in a more thorough knowledge of the area, from which both manufacturers and end users will be able to benefit. From the energy point of view, this method will have a certain direct bearing on agriculture. Another, indirect effect lies in the prospect of saving energy for the production of fertilizer.
SUPPORTED BY Styrelsen for Teknisk Utveckling

2.0351,
ANALYSES OF SECONDARY TRANSPORTATION SYSTEM APPLICABLE TO WHOLE TREE UTILIZATION PRACTICES IN LOGGING

R. Hansen, Swedish Logging Res. Fondation, *Drottninggatan 97, S11360, Stockholm, Sweden*

OBJECTIVE: A recent joint Government-Forest Industry project concerning whole tree utilization has indicated great potentials for additional raw materials for fiber and energy purposes. However, the properties of these new assortments - such as low bulk density and high degree of contamination create many new problems. The economic effects of these are especially noticable in the secondary transportation phase of logging. The chief objective of this project thus is to establish the needs and specifica-

tions for future technical and organizational development of transportation systems for these new assortments.

APPROACH: On the basis of data from a number of field studies a variety of transportation systems will be simulated in computer and analyzed.

INTENDED USE OF RESULTS: The results should give: government and industry parts of the basis for evaluating the accessiblity of new raw materials for fiber and energy; manufacturers a basis for the development of transport equipment and operators a basis for choosing between and making the most efficient use of equipment already available.

SUPPORTED BY Transportforskningsdelegationen

2.0352,

SAMPLING TECHNIQUE FOR DETERMINATION OF POLYCYCLIC AROMATIC HYDROCARBONS (PAH) PARTICLES AND GAS PHASE BY EMISSION FROM BOILERS

J. Bergstrom, Swedish Steam Users Assn., *Box 8133, Stockholm, Sweden*

OBJECTIVE: The purpose is to find a representative sampling method for PAH in flue gases. We will also try to find the distribution of PAH between particles and gas phase and the total PAH emission from different fuels.

APPROACH: This is the first stage of the project 3066 34 PAH AF. In this stage we will try different sampling techniques on a convertible boiler using different fuels, for example chips and peat briquettes. Our intention is to do a careful documentation of the operating conditions.

INTENDED USE OF RESULTS: The report will be sent to The Board for Energy Source Development but will also be available for other committees and investigators who are interested in the same problem. The results will be used in further development of the sampling technique but will also probably explain the connection between the operating conditions and the PAH emission and give a basis for establishing an acceptable emission level.

SUPPORTED BY Namnden for Energiproduktionforskning

2.0353,

LOGGING, TRANSPORT AND PREPARATION OF FOREST BIOMASS FOR ENERGY PRODUCTION

P.O. Nilsson, Swedish University of Agricultural Sciences, Operational Efficiency, *S77073 Garpenberg, Sweden*

SUMMARY OF PROJECT: The scope of the project is to further study and develop systems for logging, transport, storing and preparation of forest biomass for energy production. Special attention is paid to systems which are found interesting in the project 'System analysis of Forest Biomass in Energy Production'. (National Swedish Board for Energy Source Development project number 53 3065 161.) Primarily the studies ought to be concentrated on transport of whole trees and delimbing at lower landings or at the mill logging systems for small scale operations (farm-forestry), and logging systems for coppice ('mini-rotation forestry').

The nature of the studies depends to a great extent on the possibilities to cooperate with forest enterprises and machine manufacturers.

SUPPORTED BY Namnden for Energiproduktionforskning

2.0354,

THE USE OF STRAW AS FUEL

I. Jansson, Swedish University of Agricultural Sciences, Faculty of Agriculture, Farm Buildings, *Box 624, S22006 Lund 6, Sweden*

This project embraces a system study mapping out the development work which has been carried out abroad on the use of straw as fuel.

The study includes determining: Supply of straw in various parts of the country. Methods for collecting and transporting straw. Methods for drying and storing straw. Firing (including preparation, if any). Disposal of residual products.

The study will include contacts with research and development institutions in Sweden and abroad in the form of a target-oriented study trip.

The investigation should lead to a development program primarily aimed at supplementing the available know-how.

The project will be operated jointly with the Swedish Institute of Agricultural Engineering.

SUPPORTED BY Statens Rad for Byggnadsforskning

2.0355,

DEVELOPMENT OF SYSTEMS FOR LONG-TERM ANALYSES OF THE DEVELOPMENT OF THE SWEDISH FOREST RESOURCES (THE HUGIN PROJECT)

G.R. Bengtsson, Swedish University of Agricultural Sciences, Faculty of Forestry, Forest Survey, *S-901 83, Umea, Sweden*

OBJECTIVE: To develop and evaluate methods for long-term forecasts (100 years) of timber yield and to construct a computerized system for analyses of the future development of the Swedish forest resources.

APPROACH: Traditional methods in forest yield research are used. Various methods for growth forecasts will be evaluated and compared and the effect on tree growth by different silivicultural treatments is studies. Existing information on the dry matter content of various tree species will be modified and included in the computer system. Data from the National Forest Survey will be used for describing the present status of the forests as a basis for the forecasts.

PROGRESS: The project was started in 1976, financed by the College of Forestry, the Swedish Pulp and Paper Association and the Swedish Council for Forestry and Agricultural Research. The National Board for Energy Source Development supports the project since July 1st, 1978. The progress of the project has been reported twice a year (in Swedish). Results are presented in reports from the College of Forestry. A general description of the project and the research approach is available in English (15 p).

INTENDED USE OF RESULTS: The computer system mentioned can be used by state agencies and others to calculate the potential future yield and cut in our forests and how the yield can be increased by various treatments. The annual amount of various biomass components (stem wood, bark, branches, needles, stumps and roots) can be calculated and divided into industrial wood and biomass for energy production.

SUPPORTED BY Namnden for Energiproduktionforskning

2.0356,

INVENTORY OF BIOMASS FOR FUEL - PHASE I

K. Janz, Swedish University of Agricultural Sciences, Faculty of Forestry, Forest Survey, *S-901 83, Umea, Sweden*

OBJECTIVE: The whole project is to provide all information needed for the assessment of: (1) areas suitable for growing wood for energy production and (2) existing quantities of wood suitable for energy production. Criteria for selection of suitable area and wood resources are to be specified by experts on nature conservation, on growing wood for energy production, on machine construction and on energy production and by land owners.

APPROACH: Main elements of the projects are: (1) Identify information needed and define criteria to be used. (2) Collect and evaluate existing knowledge. (3) Collect further information needed. (4) Forecast future prospects as to the availability of wood for energy production.

INTENDED USE OF RESULTS: Decision making in Swedish energy policy.

PHASE 1: Prepare plan for the whole project covering a period of at best 3 years. Prepare data collection in conjunction with the field work 1978 of the Swedish National Forest Survey.

SUPPORTED BY Namnden for Energiproduktionforskning

2.0357,

ENERGY RECOVERY FROM BIOLOGICAL WASTE

H. Ljunggren, Swedish University of Agricultural Sciences, Inst. of Microbiology, *S75007 Uppsala 7, Sweden*

No summary has been provided to the Smithsonian Science Information Exchange.

SUPPORTED BY Styrelsen for Teknisk Utveckling

2.0358,

ASSESSMENT OF THE ECOLOGICALLY RESTRICTED EXTRACTABLE QUANTITIES OF FORESTRY RESIDUES FOR ENERGY PRODUCTION

P.O. Nilsson, Swedish University of Agricultural Sciences, School of Forestry, Operational Efficiency, *S77073, Garpenberg, Sweden*

The scope of the project is to carry out such studies on available quantities and ecological effects of complete tree utilization which are necessary for a realistic judgment of the accessable quantities considering relevant restrictions.

SUPPORTED BY Namnden for Energiproduktionforskning

2.0359,

SYSTEMS ANALYSIS OF ALTERNATIVES TO CONVERT FORESTRY RESIDUES AND COPPICE TO FUELS

P.O. Nilsson, Swedish University of Agricultural Sciences, School of Forestry, Operational Efficiency, *S77073, Garpenberg, Sweden*

The scope of the project is to perform a complete system analysis of alternatives for harvesting, transport, handling, storing, preparation and conversion of forest biomass (forest residues as well as special energy production forests) to usable energy carriers. The criteria in the analysis are mainly capital investments, costs, labor requirements, energy consumption and environmental consequences.

SUPPORTED BY Namnden for Energiproduktionforskning

2.0360,

DEVELOPMENT OF CHIPPERS

T. Gustavsson, Thord Ab Gustavsson Finmek., *Box 5235, S-891 05, Ornskoldsvik, Sweden*

No summary has been provided to the Smithsonian Science Information Exchange.

SUPPORTED BY Styrelsen for Teknisk Utveckling

2.0361,

VISUALIZATION OF THE INFLUENCE OF THE SHORT-ROTATION FORESTRIES ON THE NATURAL SCENERY

F. Molin, Tyrens Foretagsgrupp Ab, *S10340 Stockholm, Sweden*

The purpose of the project is to try to describe, with illustrations and texts, the influence of the short-rotation forestries on the natural scenery. How human beings aesthetically react to short-rotation forestries close at hand and at some distance in a landscape. From the descriptions it will then be possible to lay down the general outlines for the adaptation of the short-rotation forestries to the natural scenery.

SUPPORTED BY Namnden for Energiproduktionforskning

2.0362,

ALDER IN SHORT ROTATION FORESTRY

L. Eliasson, Umea University, Dept. of Plant Physiology, *S90187 Umea, Sweden*

The aim is to get a better understanding of the nitrogen fertilizing ability of nitrogen fixing alders under conditions likely to appear in short rotation forestry.

This year cuttings of Alnus incana (L.) Moench are grown at various light and nutrient conditions, and their nitrogen fixation, nitrogen content and biomass production are measured.

SUPPORTED BY Namnden for Energiproduktionforskning

2.0363,

DRYING BARN FOR ALTERNATIVE FUELS (WOOD, PEAT, ETC.)

R. Mostrom, Umea Varmeverk Ab, Dept. of Administration, *Skolgatan 37, S90246, Umea, Sweden*

OBJECTIVE: Investigation of technical and economical conditions for development of a drying and storage construction for alternative fuels (wood, peat, etc.).

APPROACH: The project consists of four stages: 1) Investigation (in progress), 2) Practical drying experiments (planned stages), 3) Construction (planned stages), 4) Test running (planned stages).

INTENDED USE OF RESULTS: The results should give information about technical and economical conditions for drying and storage of alternative fuels (wood, peat, etc.).
SUPPORTED BY Namnden for Energiproduktionforskning

2.0364,
IMPACT OF METHANOL ON REFINERY OPERATION

A. Brandberg, Chemical Systems International Ltd., *28 St. James Sq., London, England, United Kingdom*
OBJECTIVE: Study on the economics of methanol use as a gasoline component in a hydroskimming refinery and on the production from vacuum residues.
APPROACH: Review of the future gasoline market in Sweden against the background of the West-European market considering likely development of demand of gasoline quantities and qualities.
Considering firstly the economics of the introduction of methanol in the gasoline pool in the Swedish refinery operating patterns. Secondly considering its cost of manufacture from vacuum residues in refining situations under more severe restrictions of the sulphur content of the fuel oils. Comparison with a base case without methanol.
INTENDED USE OF RESULTS: The results will be used in an effort to establish the value of methanol as a high octane gasoline blending component for comparison with its manufacturing cost.
SUPPORTED BY Namnden for Energiproduktionforskning

2.0365,
ECONOMICAL LIMITS OF TIMBER PRODUCTION IN LOW PRODUCTIVITY FORESTS

D. Bekar, University of Skoplje, *Skoplje, Yugoslavia* (FS42-E30-32)
OBJECTIVE: Determine the circumstances under which degraded and low productivity forests can be economically managed for commodity production.
APPROACH: In several low productivity areas in Yugoslavia, the investigators will analyze records of plots in forests now degraded to various degrees. Estimates will be made of present volumes and values of timber, increases in volume and value resulting from forest management treatment, and treatment and annual costs. From this data, they will determine the minimum conditions that justify investments in timber management by means of rate-of-return on investment computations.
PROGRESS: Substantial progress has been made in the following areas: 1. Description of the condition and species composition of the low-quality stands sampled. 2. Measurement of stand structure (basal area, stocking, volume, diameter and height distributions) and height and diameter growth. 3. The quality of present timber, potential uses, and harvesting and processing costs. 4. Markets for the products that may be cut from these forests, competitive products, and likely prices for the forest products. Prospects of production of industrial wood from these forests are bleak. Though the wood is frequently cut for fuel by local villagers who do not value their time as a cost, cutting of fuelwood is not profitable as a commercial enterprise. Fuelwood cannot be produced and sold in larger towns at prices competitive with coal, oil, and electricity. In a 6-acre harvest, of relatively good forest, studies showed that about one-fourth of the wood was usable for sawlogs, mine timbers, orchard poles, and vineyard posts. All but 5 percent of the rest was usable for fuelwood. Smaller and more degraded forests yielded little but fuelwood.
SUPPORTED BY U.S. Dept. of Agriculture, Forest Service, Washington Office Forest Service

UTILIZATION OF GEOTHERMAL, WIND, OR OTHER NONFOSSIL ENERGY SOURCES

3.0001,
UTILIZATION OF GEOTHERMAL ENERGY RESOURCES IN RURAL ALASKAN COMMUNITIES

R.B. Forbes, University of Alaska, Fairbanks Campus, Geophysical Inst., *Fairbanks, Alaska* 99701
To conduct reconnaissance studies of several Alaskan geothermal spring areas to determine their potential for producing geothermal power, use in agriculture, and heating for small communities.
SUPPORTED BY U.S. Dept. of Energy

3.0002,
VEGETABLE IMPROVEMENT FOR INTERIOR ALASKA

D.H. Dinkel, University of Alaska, Fairbanks Campus, School of Agriculture & Land Resource Management, Dept. of Horticulture, *Fairbanks, Alaska* 99701 (ALK44418)
OBJECTIVE: Evaluate and select new vegetable cultivars for Interior Alaska for home garden, greenhouse, commercial and processing use. Develop improved nutrition and cultures for new and standard cultivars. Evaluate the climatic and soil factors on growth of vegetables in the greenhouse and outdoor culture.
APPROACH: Vegetable cultivars from the many breeding programs thoughout the world, especially from similar northern latitudes will be evaluated and compared using the best known cultural practices. The soil temperature, soil moisture and long cool sunlight environment will be studied in relationship to vegetable growth, yield, and quality and to nutritional requirements. Major attention should be given to devising techniques to utilize the vast quantities of geothemal and waste heat energy for the production of vegetable crops in greenhouse, outdoor soil heated areas and for processing.
PROGRESS: The Nutrient Film Technique of hydroponics was used in combination with HID lighting for controlled environment production of tomatoes, peppers, lettuce and cucumbers. Tomato production and quality were good and cucumber production unsatisfactory.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Alaska

3.0003,
COST COMPONENTS AND MARKETING MARGINS

T. Mullins, University of Arkansas, Fayetteville Campus, U.S. Dept. of Agriculture Commodity Economics Div., Grains Program Area, *Fayetteville, Arkansas* 72701 (CE-04-032-05-01)
OBJECTIVE: Estimate cost components by geographic areas for all phases of production, processing, and handling of grain. Develop a system for maintaining and updating cost data.
APPROACH: Estimate cost component data needed in the overall analysis of the grains subsector. Develop and coordinate a system of cost data that would be linked internally in grains sector and externally with other commodity sectors.
PROGRESS: Work continued during the year on development of marketing spreads and cost components for producing and processing various commodities. Cost components for bread were estimated and published for 1974. Estimates of 1974 energy use in grain production were completed in cooperation with other CED Program Areas and NEAD. Evaluation of alternatives for conserving energy in drying grain was also essentially completed. Work was inititated to analyze energy conservation practices in other aspects of grain production.
SUPPORTED BY U.S. Dept. of Agriculture, Economics Statistics & Cooperatives Service, Commodity Economics Div.

3.0004,
USE OF THERMAL EFFLUENT IN THE CULTURE OF CRUSTACEA AND FISHES

J. Vanolst, California State University & Colleges, San Diego State University, School of Sciences, Dept. of Biology, *5402 College Ave., San Diego, California* 92115
OBJECTIVES: Our major objectives are to develop techniques for the culture of the American lobster, Homarus americanus, and to assess the benefits and problems involved in using thermal effluent as an economical source of heat to accelerate growth. We will evaluate several types of culture systems in order to assess accurate heating, pumping, maintenance, and labor costs. We will also evaluate the growth, survivorship, and condition of lobsters cultured in these systems. We will determine the biological effects of physical and chemical conditions associated with thermal effluent in culture systems. The ability of lobsters to tolerate chronic elevated concentrations of waste products will be assessed in order to allow us to design adequate filtration systems. Research will be conducted on mass rearing of juveniles in warmwater systems, emphasizing reduction of cannibalism. Related research will continue on feeding requirements and methods of managing brood stock involving a series of critical problems that must be solved before commercial lobster farming can be conducted successfully. A detailed experiment to assess the dietary protein requirements of lobsters will be conducted at our laboratory in cooperation with UC-Davis and Foremost Foods. In conjunction with Foremost, a consumer-acceptance evaluation will be conducted for marketing lobsters of 1/4-1/2 pound.
HOW INFORMATION WILL BE APPLIED: Information obtained in the critical areas of research which we have identified will contribute directly to the successful development of a lobster-farming industry. Development and evaluation of the culture systems will be particularly valuable. Techniques to utilize thermal effluent will help to minimize production costs and reduce significantly the time required to produce lobster of marketable size. Use of essentially cost-free thermal effluent from power plants accelerate growth, thereby markedly reducing production time, shows outstanding promise. Such beneficial secondary use of thermal effluent will be of direct value to the electric utilities industry. Successful aquaculture using thermal effluent may be a positive means of compensating for adverse ecological effects of the effluent.
ACCOMPLISHMENTS DURING PAST TWELVE MONTHS: Growth of lobsters is accelerted by the use of thermal effluent.
SUPPORTED BY U.S. Dept. of Commerce, National Oceanic & Atmospheric Admin., Sea Grant Office

3.0005,
ENVIRONMENTAL STUDIES AT THE GEYSERS GEOTHERMAL SITE, CALIFORNIA

J.T. Wells, Pacific Gas & Electric Co., Dept. of Engineering Research, *San Ramon, California* 94583
Description: To investigate the impact of hot steam geothermal development at The Geysers, California, on the terrestrial and aquatic plants and animals of the area.
SUPPORTED BY Pacific Gas & Electric Co.

3.0006,
ANALYSIS OF THE IMPACT OF U.S. FOOD PRODUCTION OF CHANGING ENERGY PRICES AND AVAILABILITY - A SIMULATION FOR 1977-1990 USING AGRIMOD

A.H. Levis, Systems Control Inc., *260 Sheridan Ave., Palo Alto, California* 94306 ((C974) T01)
The potential impacts on the U.S. food production sector of increasingly scarce and expensive energy inputs will be assessed by simulating a Baseline Future Scenario (1977-1990) using AGRIMOD. This is a new dynamic simulation model designed to provide makers with a quick-response tool for analyzing the effects of alternative policies on U.S. agriculture. The sensitivity of the results to changes in weather patterns will be assessed by simulating three weather scenarios. The results of the simulation and their analysis will be presented in a report. A meeting will also be arranged where the outcome of the study will be presented to users from appropriate agencies.
SUPPORTED BY U.S. National Science Foundation, Div. of Policy Research & Analysis

3.0007,
SOIL INTERPRETATIONS AND SOCIO-ECONOMIC CRITERIA FOR LAND USE PLANNING

J.G. McColl, University of California, Berkeley Campus, Agricultural Experiment Station, Dept. of Soils & Plant Nutrition, *Berkeley, California* 94720 (CA-B#-SPN-2848-RR)
OBJECTIVE: Determination of physical and socioeconomic causes and consequences of encroachment of urban activities upon rural lands. Identification and organization of the kinds of data and interpretations needed by present and potential clientele who use soil-behavior and soil-landscape data. Evaluation of the adequacy of present basic and interpretive data being offered for land use planning, and development of additional, critically needed quantitative data, interpretations and alternative procedures for overcoming soil limitations.
APPROACH: After a preliminary study of changes in land use patterns in California, specific areas will be selected for study which have differing patterns of land use changes, soil and landscape patterns, and degrees of economic dependence upon agriculture.

Multivariate and other statistical analyses will be employed to determine those variables which influence various parameters of land use. Alternative land use patterns for selected areas will be developed with local agencies and evaluated in terms of conflicts in land use. Decision makers involved in land use changes and policy will be identified and pertinent data, interpretations and methods of presentation developed according to their needs. Critical evaluations, new data and interpretations will be developed on land and soil properties useful in land use plans.
PROGRESS: Relationships between land-use changes and soil properties have been documented for selected areas of Calaveras Co., CA, which is typical of many areas of the Sierra foothills and mountains which are experiencing major changes in land-use. Changes were delineated from two sets of aerial photographs, taken in 1944 and 1969, a period in which rapid urban expansion and leisure-home development have occurred. Consequences of these changes with particular attention to soil characteristics are being assessed using overly-maps, and by statistical analyses. Basic soil information was obtained from recent soil-vegetation surveys. Success or failure of residential septic-tank filter-fields is being assessed with reference to limiting soil properties, using contingency table analyses and related statistical-computer techniques. Studies of possible consequences of the exploitation of geothermal energy sources in the Big Canyon Creek Watershed, Lake Co., CA have also been conducted, and a report has been accepted for publication.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, California

3.0008,

BIOLOGICAL INDICATORS OF ENVIRONMENTAL QUALITY IN CALIFORNIA LAKES AND STREAMS

V.H. Resh, University of California, Berkeley Campus, Agricultural Experiment Station, Dept. of Entomological Sciences, *Berkeley, California* 94720 (CA-B#-ENT-3806-H)

OBJECTIVE: Develop the concept of biological indicators of environmental quality as applied to California's lake and stream environments. Analyze the effect of potential impacting activities (e.g. geothermal energy development, organic and heavy metal effluents) on the energy transfer processes in aquatic ecosystems.
APPROACH: Streams and lakes throughout California will be selected for study. A statistically-sound sampling regime will be developed for quantitative biotic collections and measurements of key water chemistry and physical parameters. Diversity indices, production estimates, and bioassay procedures will be applied in specific cases. A matrix data arrangement will be developed in which biological information, water chemistry measurements, and physical parameters can be used in preparing predicitive models of the dynamic interactions occurring in these environments.
PROGRESS: Research projects underway include 1) an analysis of environmental factors influencing spatial distributions, secondary production and instantaneous growth rates of the seepage fauna in springs located at the University of California Hopland Field Station; 2) environmental effects of large scale aeration on the benthic fauna of Clear Lake; community diversity, substrate influences on benthic spatial distributions, and analysis of meteorological factors affecting aquatic insect communities in the McCloud River; 3) an analysis of the effects of geothermal energy development on aquatic biota in the Geysers area of California.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, California

3.0009,

AN EVALUATION OF THE EFFECTS OF GEOTHERMAL ENERGY DEVELOPMENT ON AQUATIC BIOTA IN THE GEYSERS AREA OF CALIFORNIA

V.H. Resh, University of California, Berkeley Campus, School of Natural Resources, Dept. of Entomological Sciences, *Berkeley, California* 94720

This study has been designed to evaluate the effects of the development and operation of geothermal energy power plants on the community organization and the energy transfer processes of aquatic benthic organisms in streams of the known Geothermal Resource Area (KGRA) Geysers, California. At selected stations, instantaneous growth rates, production and turnover ratios will be estimated for dominant benthic species and the entire benthic community. Physical parameters such as sedimentation rates and chemical measurements including ammonia, boron, arsenic, and mercury concentrations will be incorporated into a data matrix arrangement to develop a predictive model of the interactions occurring in these environments. Study sites will include: 1) streams that have received sediment and other materials from geothermal power plant construction and operating procedures; 2) streams that are adjacent to natural fumarole areas and received heated effluents prior to geothermal development; 3) streams that have received effluents from cinnabar mining operations; 4) streams that have received both geothermal and cinnabar effluents; 5) streams that have received no effluents. The results of this study will develop methods of using biological indicator organisms, particularly in analyzing any cumulative effects of the geothermal energy plants on aquatic biota.
SUPPORTED BY U.S. Dept. of the Interior, Office of Water Research & Technology

3.0010,

IMPERIAL VALLEY ENVIRONMENTAL PROJECT GEOTHERMAL - SOCIOECONOMIC ASSESSMENT

C.H. Hall, University of California, Central Office, Lawrence Livermore Lab., Environmental Sciences Div, *P.O. Box 808, Livermore, California* 94550 (W-7405-ENG-48)

The objective is to determine the probable effects geothermal resource development will have on and from the local social-cultural system, land use patterns, institutional and leadership structure, economic, fiscal and public facilities systems. The present Imperial County economy is dominated by field and row crop and livestock production in a desert valley entirely dependent on irrigation. Primary socioeconomic effects of geothermal resource development include increased demand for water as a coolant, power plant emission damage to crops, displacement of land from agricultural production, water quality degradation, displacement of agricultural workers, influx of relatively skilled construction and operation workers, subsidence and potential damage to gravity irrigation and drainage systems. Secondary effects include 'spinoff' industries which may directly use geothermal heat, power or chemicals, effect on contiguous property values and taxes and effects on existing recreation activities. Tertiary effects include commercial and construction activity induced by direct and secondary industrial development. Other factors include cumulative impacts on public facilities and service systems, revenue and cost distribution effects, relationship to local land use planning, effects and constraints posed by social-cultural, institutional and leadership structures. A variety of analytical frameworks and models are being reviewed to assist in the characterization, forecast and analysis of socioeconomic system components, including an existing input-output model of the county economy. Special studies are being conducted of the fiscal impacts, recreation impacts and leadership interviews and attitudinal analysis.
RESULTS: A characterization of existing (pre-geothermal resource development) conditions is being published. A series of scenarios of power plant distribution and siting under a variety of constraints has been developed.
SUPPORTED BY U.S. Dept. of Energy, Div. of Technology Overview Integrated Assessment

3.0011,

INTEGRATED ASSESSMENT PROGRAM OF THE IMPERIAL VALLEY ENVIRONMENTAL PROJECT

D.W. Layton, University of California, Central Office, Lawrence Livermore Lab., Environmental Sciences Div, *P.O. Box 808, Livermore, California* 94550 (W-7405-ENG-48)

The primary objective of the Integrated Assessment Program is to assess the impacts upon the physical and human environments of the Imperial Valley, California due to geothermal energy production. In order to carry out this objective, two basic tasks have been undertaken: (1) collection of relevant background information on the valley for assessment activities and (2), development of a set of geothermal energy scenarios which include power schedules, technology characterizations, and siting criteria.
Assessments of the alternative geothermal scenarios will focus on air quality changes, air pollution effects on selected agricultural crops, water resource impacts, and finally, social and economic impacts. The results of those impact studies will then be evaluated to determine potential problems as well as possible solutions. Results of the research will be transferred to decision makers in a timely fashion so that proper consideration can be given to the various consequences of geothermal energy development.
RESULTS: Work has been completed on a Gaussian air pollution model which describes the behavior of pollutants due to atmospheric dispersion, deposition, and chemical reactions. In addition, a model that is able to describe the effects of air pollution on crop growth has been developed. An initial study of water supply dilemmas has also been finished.
SUPPORTED BY U.S. Dept. of Energy, Div. of Technology Overview Integrated Assessment

3.0012,

IMPERIAL VALLEY ENVIRONMENTAL PROJECT GEOTHERMAL - WATER QUALITY

K. Pimentel, University of California, Central Office, Lawrence Livermore Lab., Dept. of Mech Engin, *P.O. Box 808, Livermore, California* 94550 (W-7405-ENG-48)

The objective of the water quality element of the Imperial Valley Environmental Project is to collect data needed to assess the potential and actual impact of geothermal resource development on the Valley's water system. The Imperial Valley economy is based upon an agricultural system which is dependent upon the importation of water from the Colorado River. Underlying the agricultural lands are major geothermal resources containing hot and highly saline fluids. As water quality is already an issue of major concern in the Valley, the potential impact of geothermal development must be carefully evaluated. This is being done by collecting baseline data on existing water quality, setting up monitoring networks in the vicinity of geothermal sites, and by developing methods of recognizing possible contamination of water with geothermal fluids through pattern recognition of chemical constituents. The collected data will also be used to support computer-assisted modeling of surface and ground water pollutant transport.
RESULTS: Valley-wide and site-specific sampling networks have been established, and are being sampled montly. The samples are being analyzed for major chemical constituents, and trace constituents of special interest.
SUPPORTED BY U.S. Dept. of Energy, Div. of Technology Overview Integrated Assessment

3.0013,

IMPROVED GREENHOUSE PRODUCTION SYSTEMS

H.C. Kohl, University of California, Davis Campus, Agricultural Experiment Station, Dept. of Environmental Horticulture, *Davis, California* 95616 (CA-D#-EHT-3334-H)

OBJECTIVE: Devise a greenhouse system oriented to the use of geothermal energy and thermal polluting water, coolant from nuclear power generating reactors and to the special problems of arid climates. Devise greenhouse production systems oriented to the needs of the amateur plant grower.
APPROACH: Index cultivars of ornamental plants according to maximum, minimum and optimum temperature requirements in order to provide information for development of energy conserving modifications of current greenhouse growing systems. Devise and test crop production systems which utilize multiple layers of plants (particularly at night) to make most efficient use of heated space. Devise a greenhouse system oriented to the use of geothermal energy and thermal polluting water, nuclear power, generating reactors and to special problems of arid climates. Devise greenhouse production systems oriented to the needs of the amateur plant grower.
PROGRESS: During 1976 primary interest was focused on energy-saving production systems. Chrysanthemums were used as the test plant for investigation of both systems. The systems were: 1. Normal night temperature with unheated glass during the day which would represent a practical system of conveying plants to a small, highly insulated room at night and redistributing over a larger area for the daylight hours. Such a situation in Davis in the sunny days of late winter indicated normal bloom and timing for plants so treated despite about 10% lower cumulative degree-hour base. 2. Normal day temperature with very low (i.e. 42 F) dark temperature for 16 hours each night. Results of first experiments indicate that with 23 nights at normal temperature followed by 42 nights to bloom as much as a 50% fuel saving could have been obtained with only a 17% delay in harvest date. Even more important,

only 42 nights following bud initiation at normal night temperature led to essentially normal flowering with time delay as the only drawback.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, California

3.0014,
ECOPHYSIOLOGY OF DESERT ANTHROPODS

E.B. Edney, University of California, Los Angeles Campus, Lab. of Nuclear Medicine & Radiation Biology, *900 Veteran Ave., Los Angeles, California* 90024

Sampling over long periods together with recording of abiotic data. Experimental manipulation of conditions including temperature, moisture, salinity and pollutants concentrations. Measurement of degradation in presence and absence of various faunal components. Field and laboratory studies on these questions.Information about the significance of soil anthropods in desert ecosystems, and about the effect of pollutants from fossil fuel or geothermai sources upon them. Information about population dynamics and trophic relationships of soil anthropods.
SUPPORTED BY U.S. Dept. of Energy, Div. of Biomedical & Environmental Research

3.0015,
RADIONUCLIDE AND STABLE ELEMENT CYCLING

E.M. Romney, University of California, Los Angeles Campus, Lab. of Nuclear Medicine & Radiation Biology, *900 Veteran Ave., Los Angeles, California* 90024

Several interacting studies form the basis of this research program. Work is proceeding along the following lines in response to mission needs of ERDA: (a) define the manner in which plants function in the vegetation-carrier transport of plutonium and other transuranic elements through the food chain from contaminated soil, (b) characterize the patterning, association and distribution of desert vegetation as influenced by nutrient gradients and other edaphic factors, (c) investigate the cycling of non-nuclear trace element pollutants in soils and vegetation, and (d) establish baseline assessments of such elements in natural ecosystems near geothermal resource areas (KGRA's) in the Imperial Valley, CA.We shall continue to obtain information concerning ecosystem radionuclide cycling of the transuranic elements Pu-239-240 and Am-241. Work which has been underway in conjunction with the US/IBP Desert Biome Program shall be organized into final reports and papers for publication. Related soil-plant studies contributing basic information on the structure and function of the desert ecosystem shall be continued in order to obtain necessary information to complete several research papers and monographs in preparation for publication from these basic studies. New geothermal-related work started in FY 1976 shall be directed toward trace element surveys in natural vegetation, native animals, and key agricultural crops as part of the ecological baseline assessments work underway at KGRA sites in the Imperial Valley.(a) Complete an estimate of the inventory and geographical distribution of transuranic elements in the vegetation of fallout areas at the Nevada Test Site. Our work in 'safety shot' sites is expected to be complete during FY 1977 and shifted to nuclear events sites for continuation during FY 1978. (b) Initiate during FY 1977 terrestrial desert ecosystem cycling studies of trace element pollutants identified from surveys of fly ash disseminated from a coal-fired power generating station. (c) Complete during FY 1977 base-line ecological studies involving producer-consumers at the East Mesa KGRA geothermal study site in the Imperial Valley, CA.
SUPPORTED BY U.S. Dept. of Energy, Div. of Biomedical & Environmental Research

3.0016,
THE PHYSIOLOGY AND ECOLOGY OF DESERT AND OTHER PLANTS

A. Wallace, University of California, Los Angeles Campus, Lab. of Nuclear Medicine & Radiation Biology, Environmental Biology Division, *900 Veteran Ave., Los Angeles, California* 90024 (E(04-1)GEN-12)

The objectives of this project are threefold: (1) To provide environmental baseline data for soils and plant processes in the desert ecosystem representative of the southwestern U.S.A. These complement with other on-going studies in the division to provide a reasonably complete ecosystem approach to southwestern deserts. The information is vital to programs leading to both preservation and restoration of native systems. (2) To support the major objective with laboratory studies of trace metal and radionuclide effects and transport rates in the soil-plant system. (3) To respond to needs of DOE with environmental assessments research in solving problems related to fossil fuel, nuclear and geothermal technologies. The approaches of this study are threefold: (1) Ecophysiology of desert plants - processes of photosynthesis, transpiration, nitrogen, and mineral cycling, carbon budget, population dynamics and root growth and activity are studied. (2) Laboratory and field studies of trace metal and radionuclide uptake and translocation rates and effects are conducted. Special emphasis is given to determine the threshold acute and chronic toxicity levels of various trace metals and transuranium elements in plants. (3) Field studies continue of natural desert ecosystems in the Nevada Test Site and in the Imperial Valley Geothermal Test Area.

RESULTS: The project is ongoing and the results are published year by year in scientific journals.
SUPPORTED BY U.S. Dept. of Energy, Div. of Biomedical & Environmental Research

3.0017,
BEHAVIOR OF HYDROGEN SULFIDE IN THE ATMOSPHERE AND ITS EFFECTS ON VEGETATION

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This is a continuation of a study started in FY 1975 under NSF/RANN Grant 75-15711. The goals of the original study and the present one are: (1) to define the atmospheric concentrations of Hydrogen sulfide which cause damage to plants and (2) to study the persistence of the gas in the atmosphere. Production of geothermal fluids does result typically in the release of hydrogen sulfide to the atmosphere. The presence of this malodorous and noxious gas is of concern to enviromentalists and agriculturalists. Year I of this research demonstrated that both rapid- and slow-growing plants are damaged by exposure to atmospheric concentrations of hydrogen sulfide in the range of 30-300 ppb. In Year II, more precise limits at which damage occurs will be defined. This work is being done by continuous fumigation of plants in greenhouses with a mixture of hydrogen sulfide and carbon-filtered air. Emphasis in Year I was on wild flora. In Year II, experiments will include agricultural crops, viz., lettuce and sugar beets. The mechanisms responsible for physiological damage will be studied by sulfur analysis of plant fractions. The fate of hydrogen sulfide is being researched through literature surveys and through cooperative laboratory studies with California Statewide Air Pollution Research Center. At the conclusion of this 12-month project, data will be available to indicate if ambient levels of hydrogen sulfide at geothermal facilities are capable of producing damage to a number of different common plants (alfalfa, grape, lettuce, sugar beets, Ponderosa pine, Douglas fir, pinto bean, maple, California buckeye).
SUPPORTED BY U.S. National Science Foundation, Div. of Advanced Environmental Research & Technology

3.0018,
REVIEW OF WIND ENERGY APPLICATIONS IN AGRICULTURE

R.N. Meroney, Colorado State University, School of Engineering, Dept. of Civil Engin, *Fort Collins, Colorado* 80523 (1090-20402-001-A)

OBJECTIVE: Identify the best approach to be used for investigating the use of wind power in agriculture.

APPROACH: The Federal research program on agricultural wind power will be reviewed to determine the best organizational structure to be used to ascertain that all significant areas of research are considered. Statements of work for various aspects of the Federal program will be reviewed for adequacy, and proposed extramural research studies will be reviewed to recommend studies which maximize the expected research productivity.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Beltsville Agricultural Research Center

3.0019,
A WINDMILL POWERED HEAT PUMP IN A DAIRY FARM APPLICATION

G.B. Curtis, Kaman Sciences Corp., *1700 Garden of the Gods Rd., Colorado Springs, Colorado* 80907 (1090-20404-001-C)

OBJECTIVE: Design, construct, and operate a windmill powered generating system adapted to the existing dairy facilities at Colorado State University, Fort Collins, Colorado, to cool milk and heat water; measure the performance of the system as it relates to local wind conditions; and make an economic, cost, and value analysis of wind utilization in cooling milk and heating water for a dairy operation.

APPROACH: A commercially available 20-foot diameter, vertical axis wind turbine will be purchased and installed to provide wind generated electrical power to operate an existing ice builder refrigeration compressor at the Colorado State University (CSU) Experimental Dairy Farm at Fort Collins, Colorado. The CSU facility will be modified to operate the existing system as a heat pump. Other modifications will be made to transfer the heat to water for sanitation. Measurements will be made on wind conditions and the operating performance of the wind energy system. They will develop a computer model for the performance and cost analysis of the research system adapted to other sizes, locations, and applications. Periodic oral and written reports will be prepared followed by a final report at the end of the study.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Beltsville Agricultural Research Center

3.0020,
A WINDMILL POWERED HEAT PUMP IN A DAIRY FARM APPLICATION

G.B. Curtis, Kaman Sciences Corp., *1700 Garden of the Gods Rd., Colorado Springs, Colorado* 80907 (1090-20401-003-C)

OBJECTIVE: Design, construct, and operate a windmill powered generating system adapted to the existing dairy facilities at Colorado State University, Fort Collins, Colorado, to cool milk and heat water; measure thy performance of the system as it relates to local wind conditions; and make an economic, cost, and value analysis of wind utilization in cooling milk and heating water for a dairy operation.

APPROACH: A commercially available 20-foot diameter, vertical axis wind turbine will be purchased and installed to provide wind generated electrical power to operate an existing ice builder refrigeration compressor at the Colorado State University (CSU) Experimental Dairy Farm at Fort Collins, Colorado. The CSU facility will be modified to operate the existing system as a heat pump. Other modifications will be made to transfer the heat to water for sanitation. Measurements will be made on wind conditions and the operating performance of the wind energy system. They will develop a computer model for the performance and cost analysis of the research system adapted to other sizes, locations, and applications. Periodic oral and written reports will be prepared followed by a final report at the end of the study.

PROGRESS: A Darrius rotor wind turbine generator, 20-foot equatorial diameter and 30-foot high, was installed at the Colorado State University dairy farm. The induction generator on the wind turbine was connected in parallel with the utility power driving the compressor of the milk cooler. A tube cooler and parallel plate heat exchanger are used to cool the milk from the line, and the refrigeration condenser is used to heat the tempered water used for udder washdown and utility washing. The system was placed in operation, and is now operating continuously in a long-term test.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Beltsville Agricultural Research Center

3.0021,
PERFORMANCE OF WIND ROTORS USED FOR IRRIGATION PUMPING

V. Nelson, Kaman Sciences Corp., *1700 Garden of the Gods Rd., Colorado Springs, Colorado* 80907 (7091-20740-003-A(1))

OBJECTIVE: Determine the performance of a wind rotor for driving an irrigation pump; develop a computer model of a vertical axis wind rotor; determine economic feasibility of wind powered irrigation pumping systems.

APPROACH: The wind energy input to and the power output from a vertical axis wind rotor will be used to evaluate wind rotors for pumping irrigation water from wells. Wind speed measured as a function of time and height above the ground surface will provide the energy into the system. The shaft speed and torque will be measured to determine the output from the wind energy conversion system. A computer simulation model for a vertical axis wind rotor will be implemented and used to determine the optimum operating conditions for varying wind energy parameters. The wind rotor data will be used with irrigation pumping data from a cooperative study to determine the economic feasibility of wind powered irrigation in comparison to present energy sources.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Oklahoma - Texas Area

3.0022,

TECHNICAL AND MANAGEMENT SUPPORT FOR THE DEVELOPMENT OF WIND SYSTEMS FOR FARM AND RURAL USE

T. Healy, Rockwell International Corp., Atomics International Division, *P.O. Box 464, Golden, Colorado* 80401 (E(29-2)-3533)

Federal efforts to assist commercialization of small wind systems will be carried out with the utmost sensitivity to those factors which will help rather than hinder the businesses which develop and market these machines. The Department of Energy's Rocky Flats Plant (managed for DOE by Rockwell) was selected as the most suitable DOE field site for testing and coordinating the activities in this element. The primary goal of the program is to reduce the cost of energy generated by small (under 100 kW) wind systems. Specific objectives include the heavily instrumented testing of small systems, the development of advanced small systems, and the dissemination of technical information to small system users. A small wind systems test center has been established at Rocky Flats, and eight machines have undergone partial performance and reliability testing. During FY 1978, testing will continue and test data will be made available to the public. A User's Guide and indexes of wind energy researchers and available small wind systems will be published. (DOE/ET-0023/1)

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

3.0023,

FLUIDIZED-BED COMBUSTION

W.T. Harvey, U.S. Dept. of Agriculture, *12th & Independence Ave. S.W., Washington, District of Columbia* 20250 (EX-76-A-01-2488)

An intensive research program is required to evaluate the solid wastes from fluidized-bed combustion for potential use in agriculture. The work will involved detailed chemical and physical analysis of the material followed by extensive greenhouse, growth chamber and field studies.

SUPPORTED BY U.S. Dept. of Energy, Office of Fossil Energy

3.0024,

COST COMPONENTS AND MARKETING MARGINS

J.J. Naive, U.S. Dept. of Agriculture, Economics Statistics & Cooperatives Service, Commodity Economics Div., Grains Program Area, *14th & Independence Ave. S.W., Washington, District of Columbia* 20250 (CE-04-032-11-00)

OBJECTIVE: Estimate cost components by geographic areas for all phases of production, processing, and handling of grain. Develop a system for maintaining and updating cost data.

APPROACH: Estimate cost component data needed in the overall analysis of the grains subsector. Develop and coordinate a system of cost data that would be linked internally in grains sector and externally with other commodity sectors.

PROGRESS: Work continued during the year on development of marketing spreads and cost components for producing and processing various commodities. Cost components for bread were estimated and published for 1974. Estimates of 1974 energy use in grain production were completed in cooperation with other CED Program Areas and NEAD. Evaluation of alternatives for conserving energy in drying grain was also essentially completed. Work was initiated to analyze energy conservation practices in other aspects of grain production.

SUPPORTED BY U.S. Dept. of Agriculture, Economics Statistics & Cooperatives Service, Commodity Economics Div.

3.0025,

NOVEL APPROACHES TO USES OF LAND PLANTS IN THE SEA

B.Z. Siegel, University of Hawaii System, Manoa Campus, Pacific Biomedical Research Center, Dept. of Microbiology, *2538 The Mall, Honolulu, Hawaii* 96822

OBJECTIVES: We propose to initiate field tests in the use of saline water in Hawaii in areas of high lava soil content and significant drainage to cultivate selected annuals and woody perennials.

ANTICIPATED BENEFITS: The information obtained will be used to provide a basis for economic evaluation and marketing analysis in terms of foodstuff and/or energy yields. The information will be published and made available to state agricultural and environmental agencies, local Energy Research and Development Administration (ERDA) representatives, and the Marine Advisory Program.

SUPPORTED BY U.S. Dept. of Commerce, National Oceanic & Atmospheric Admin., Sea Grant Office

3.0026,

SPACE HEATING FOR COMMERCIAL BUILDINGS IN BOISE, IDAHO, AND OTHER NON-ELECTRIC APPLICATIONS OF GEOTHERMAL HEAT

R.J. Schultz, U.S. Dept. of Energy, Idaho Operations Office, Idaho National Engineering Lab., *Idaho Falls, Idaho* 83401 (E(10-1)-1375)

The primary objective of this project is to design a demonstration space heating system for public buildings in the City of Boise, Idaho. The R and D effort will: (1) determine if the local geothermal resource is adequate; (2) estimate costs and evaluate the practicality of retrofitting existing heating systems for utilization of low-temperature (less than 95 degrees C (200 degrees F)) geothermal water; and (3) design the distribution systems and the geothermal waste water discharge system. The potential for direct use of geothermal energy for industrial processing, agriculture, agriculture and other non-electric applications at the Raft River site and technology transfer opportunities to adjoining regions with similar geothermal reservoirs will be studied. A study to evaluate the feasibility of converting various building heating systems in Boise, Idaho so that geothermal water at 75 degrees C (170 degrees F) may be used as a heat source has been completed. Exploratory drilling has shown 55 degrees C (132 degrees F) temperature water at a depth of 650 feet with the temperature gradient of 1.1 degrees C (2 degrees F) every 10 feet. Preliminary analyses show that no major resource or engineering difficulties exist that would prevent successful completion of the project. A number of studies have been completed which address the potential for other non-electric applications of low-temperature (less than 150 degrees C (300 degrees F)) geothermal water of the Raft River reservoir. (ERDA-76/53/1).

SUPPORTED BY U.S. Dept. of Energy, Div. of Geothermal Energy

3.0027,

THERMAL WATER UTILIZATION IN TREE BREEDING AND WOOD PRODUCTION PROJECT

C. Wang, University of Idaho, Forest Wildlife & Range Experiment Station, *Moscow, Idaho* 83843 (IDA-ES-0090)

OBJECTIVE: Selective breeding of forest trees for improved growth rate and wood quality for the utilization of thermal water.

APPROACH: Initial field trial experiments were established at Idaho Falls ERDA site for evaluation and selection of best genotypic response in growth and their optimum cycle and level of thermal water, ground heating and other treatments. The test materials include selected clones of inter-species hybrid poplars, indigenous conifers and exotic and indigenous species for Christmas trees and ornamentals.

PROGRESS: A - Field tests for the selection of adaptable tree species and hybrid poplar clones were made at the high cold 'desert' of INEL, Southern Idaho, and the low warm 'desert' of Hanford Reservation, Eastern Washington. Identical materials of poplar clones and prairie windbreak tree species were used in the two test sites. The early results eliminated a number of the less hardy clones of NE origin. Additional materials were introduced from the prairie Provinces of Western Canada. B - Geothermal Water - This experiment is designed to test the effect of geothermal water irrigation on tree growth. The field test plantations are arranged according to a split plot design in three complete blocks, with the water temperature treatment as the whole plot and the tree varieties as the subplots. Plantation 1976-A was established in June 1976 at the Raft River Geothermal Project Site #1. It includes three complete blocks, two treatments, and three tree varieties as subplots randomly arranged within the whole plot. The three tree varieties are hybrid poplar, golden willow and green ash. The two treatments are treatment #1--sprinkler irrigation with Raft River water, and treatment #2--sprinkler irrigation with geothermal water. Plantation 1976-B will be irrigated by flood irrigation. The two treatments are treatment #3--flood irrigation with Raft River water and treatment #4--flood irrigation with geothermal water. Tree seedlings for the plantation 1976-B were delivered to planting site in May 1976.

SUPPORTED BY Idaho State Government

3.0028,

ELECTRIC DEMAND CHARACTERISTICS OF FARMS AND FARM EQUIPMENT

L.H. Soderholm, Iowa State University of Science & Technology, U.S. Dept. of Agriculture Agricultural Engineering Res. Div., *Beardshear Hall, Ames, Iowa* 50010 (3408-20400-001)

OBJECTIVE: Determine electric demand characteristics of farms and farm equipment through development and application of instrumentation techniques for demand measurement of farmstead electrical loads. Apply acquired data to energy control techniques and improvement of energy efficiency of farmstead electrical distribution systems and electrically operated farm equipment.

APPROACH: Develop and install improved demand instrumentation on farmstead electrical services to determine operating characteristics of electrical farm loads. Apply load control techniques to modify demand characteristics of farmstead electrical systems and equipment. Utilize techniques such as deposition of particulates by air ions and modification of energy input requirements by use of auxiliary sources such as wind-electric power to reduce air pollution and modify electrical demand.

PROGRESS: Material has been prepared as part of a committee effort to develop a specific Electrical Code for Agriculture to provide more suitable guidelines than the present National Electrical Code for the installation and use of electricity in agricultural applications. Problems associated with improper grounding of electrical equipment and with electrical interference caused by use of solid-state power controls have been investigated. A research project has been started to determine the modifications of electrical demand that may be made on rural electrical systems by using wind energy and heat pump systems in conjunction with energy storage.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Mid Great Plains Area

3.0029,

HEATING OF RURAL STRUCTURES WITH WIND DERIVED ENERGY

L.H. Soderholm, Iowa State University of Science & Technology, U.S. Dept. of Agriculture Agricultural Engineering Res. Div., *Beardshear Hall, Ames, Iowa* 50010 (3408-20690-001)

OBJECTIVE: Development of heating systems for rural structures using wind-derived energy to reduce consumption of other fuels for heating and to provide a degree of standby heating in case of failure of other sources.

APPROACH: Develop and install five-15-KW wind generating systems and controls as supplementary sources of heat in farm structures in conjunction with heat pumps or primary energy sources. Determine both theoretical and derived power from wind energy at specific sites. Optimize wind system and storage concepts to obtain maximum efficiency and cost effectiveness.

PROGRESS: Current efforts are directed toward the determination of the equipment and techniques that can be used for applying wind energy to the heating of rural structures to reduce consumption of nonrenewable fuel resources and to provide standby energy sources. A Grumman Windstream 25 wind generator having a 25-foot-diameter impeller and a power capacity of 15 kW has been installed at an

experimental site at Bloomfield, Iowa, in conjunction with a heat pump and water-based energy storage. The system's operational characteristics and energy output are being determined in an application to structural heating. Data for both power output and wind velocity are recorded on magnetic tape for determining system performance and wind velocity at the site.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Mid Great Plains Area

3.0030,

ANALYSIS OF WIND ENERGY APPLICATIONS IN AGRICULTURE

D.J. Wissman, Development Planning & Research Associates Inc., *200 Research Dr., Manhattan, Kansas* 66502 (1090-12201-004-C)

OBJECTIVE: Identify agricultural power and energy uses which are best potential applications of wind power and assess the technical and economic viability of wind power applications identified.

APPROACH: The study will be conducted by sequentially describing major agricultural enterprises, identifying energy and power consuming functions in each enterprise, evaluate types of energy used and levels of power, evaluate potential wind power equipment and known variations in wind power, and use an objective scoring system to rate wind energy potential of candidate applications.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Beltsville Agricultural Research Center

3.0031,

WIND ENERGY FOR PUMPING IRRIGATION WATER

L.J. Hagen, Kansas State University, U.S. Dept. of Agriculture Agricultural Research Service, Soil Erosion Res, *Dickens Hall, Room 205, Manhattan, Kansas* 66504 (3707-20740-001)

OBJECTIVE: Determine the seasonal wind energy distribution in the Great Plains and develop strategies to utilize wind energy for pumping irrigation water.

APPROACH: Analyze climatological data to determine seasonal wind energy distribution over the Great Plains. Develop a computer simulation model to explore strategies to satisfy irrigated crop water requirements using wind energy considering several energy storage possibilities and using realistic constraints on irrigation wells, pumps, and wind turbines.

PROGRESS: Continuing research concerning feasibility of wind-powered irrigation and development of a low-lift prototype system suitable for pumping shallow wells, tailwater pits, etc. indicates highest wind energies occur in the spring, but there is significant variability in seasonal energy between years. To maximize use of wind energy, cropping changes, auxiliary power sources, or alternate uses of winter and spring energy are necessary. A possible cropping change of reducing corn to one-third of the irrigated acreage and increasing winter wheat to occupy two-thirds of the irrigated acreage would permit full utilization of wind energy alone in western Kansas.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Kansas - Nebraska Area

3.0032,

COST COMPONENTS AND MARKETING MARGINS

W.G. Heid, Kansas State University, U.S. Dept. of Agriculture Commodity Economics Div., Grains Program Area, *Dickens Hall, Manhattan, Kansas* 66504 (CE-04-032-20-01)

OBJECTIVE: Estimate cost components by geographic areas for all phases of production, processing, and handling of grain. Develop a system for maintaining and updating cost data.

APPROACH: Estimate cost component data needed in the overall analysis of the grains subsector. Develop and coordinate a system of cost data that would be linked internally in grains sector and externally with other commodity sectors.

PROGRESS: Work conitued during the year on development of marketing spreads and cost components for producing and processing various commodities. Cost components for bread were estimated and published for 1974. Estimates of 1974 energy use in grain production were completed in cooperation with other CED Program Areas and NEAD. Evaluation of alternatives for conserving energy in drying grain was also essentially completed. Work was initiated to analyze energy conservation practices in other aspects of grain production.

SUPPORTED BY U.S. Dept. of Agriculture, Economics Statistics & Cooperatives Service, Commodity Economics Div.

3.0033,

RESEARCH, DEVELOPMENT & DEMONSTRATION

R. Darling, State Office of Energy Resources, *Augusta, Maine* 04330

Encourage and direct or sponsor research and experiments within the State to develop alternate energy sources, particularly, but not limited to, those sources which rely on the renewable natural resources of the State, such as the water of the tides and rivers, the forests, the winds and other sources which to date have not been fully explored or utilized.

Encourage and direct, in conjunction with private industry, the practical development and operation on a small scale of experimental projects involving alternate energy sources, in order to ascertain the potential usefulness of such alternate energy sources and their costs, provided only that such projects shall be subject to the regulations of those state agencies concerned with the protection of the environment and preservation of the natural resources of the State, and with regulation of other energy sources.

SUPPORTED BY Maine State Government

3.0034,

DEVELOPMENT OF WIND POWERED EQUIPMENT FOR AGRICULTURE

L.A. Liljedahl, U.S. Dept. of Agriculture, Agricultural Research Service, Agricultural Environmental Quality Inst., Physical Control Lab., *Bldg. 303, Beltsville, Maryland* 20705 (1109-20400-001)

OBJECTIVE: Develop economic equipment to utilize wind power to cool milk and heat water on a dairy farm.

APPROACH: A windmill will be designed and built to provide power to several requirements at a dairy farm. Tests will be conducted to determine its suitability for this application, the operating characteristics of the system, local wind characteristics, and accuracy of design assumptions. Modifications will be made to improve performance or reduce cost as needed.

PROGRESS: Analysis of the vibrational modes of a 60-foot freestanding communication tower indicated that its modes are well separated from driving frequencies produced by either a 2- or 3-bladed, 32-foot diameter wind turbine. Further analysis showed that best load matching of a wind turbine driving refrigeration equipment could be achieved with two compressors having capacities in the ratio of the square root of three, driven with variable speed drive units. A friction loss analysis showed maximum friction loss would not exceed about 35%, which would occur at cut-in wind speed.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Beltsville Agricultural Research Center

3.0035,

WOOD COMPONENTS FOR WIND ENERGY SYSTEMS

R.B. Hoadley, University of Massachusetts, Amherst Campus, Agricultural Experiment Station, Mcintire Stennis Program, *Amherst, Massachusetts* 01002 (MAS00023)

OBJECTIVE: Develop construction details and fabrication procedures for machine blades in wind energy systems. Develop use of wood support tower structural systems for wind power generators.

APPROACH: Engineering requirements of stress capabilities and weight distributuon to be determined by Civil Engineering Department. Wood technologists to select wood species and develop fabrication procedures. Civil Engineers will test wood propeller blades on wind power electricity generators.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Massachusetts

3.0036,

HEAT ENGINES USING ELASTOMERS AS THE WORKING SUBSTANCE

R.J. Farris, University of Massachusetts, Amherst Campus, School of Engineering, Dept. of Polymer Sciences & Engineering, *Amherst, Massachusetts* 01002

Elastomers have thermodynamic properties similar to gasses but, because they are solids, they need no containment and, hence, can be adapted to extremely simple and low cost devices for the conversion of heat energy to mechanical work. Such engines can develop significant power from temperature differences of less than 20 degrees C. They may, therefore, economically utilize thermal resources which would be otherwise wasted.

The research is primarily directed toward a 1/10th horsepower elastomeric heat engine for the irrigation of small farms in certain areas of India, Bangladesh, and other countries where irrigation is seasonally required and there are ample supplies of ground water but no developed electric power or irrigation networks. Secondary goals include research toward elastomeric heat pumps for home heating and cooling, meeting the air circulation requirements of greenhouses, and helping to guide the optimizing of elastomers for heat engine and heat pump applications.

Work will include experimental engine design and testing, including heat exchange analysis, research on related polymer properties, fatigue tests and the development of the prototype 1/10th horsepower irrigation pump toward which the research is primarily directed.

SUPPORTED BY U.S. National Science Foundation, Div. of Exploratory Research & Systems Analysis

3.0037,

CLIMATOLOGY OF MICHIGAN

D.E. Linvill, Michigan State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *New Administration Bldg., East Lansing, Michigan* 48823 (MICL03070)

OBJECTIVE: Provide climatological data for understanding the influence of the Great Lakes on Michigan climate; documentation, reports, etc., used in the research and management decision process; evaluation of advertent and inadvertent weather midification activities; land use planning; crop feasibility studies; development of a computerized data source to provide adequate desing criteria for hydrological designs, erosion control, waste water management, etc.

APPROACH: Michigan climatological data will be put into a form allowing rapid computer access. Climatological summaries will be prepared from these data banks.

PROGRESS: Climatological data for the complete period of record at Adrian, Allegan, Alma, Bloomingdale, and East Lansing have been entered onto computer tape, cleaned and verified. We are continuing to add new stations to the tapes as time permits. Volunteer dense raingauge networks have been operating in several counties for the last 3 to 4 years. This data is being prepared to demonstrate macroscale precipitation variation within Michigan. Analysis of wind along Lake Michigan is underway. Hourly data from Coast Guard Stations at Ludington, Muskegon, Point Bessy and Grand Marias are available on computer tape. Dedicated sites at Hart, Michigan are being used to determine wind power potential along the lake.

SUPPORTED BY Michigan State Government

3.0038,

COST COMPONENTS AND MARKETING MARGINS

S.H. Holder, Mississippi State University, Delta Branch Experiment Station, Grains Program Area, *Stoneville, Mississippi* 38776 (CE-04-032-28-04)

OBJECTIVE: Estimate cost components by geographic areas for all phases of production, processing, and handling of grain. Develop a system for maintaining and updating cost data.

APPROACH: Estimate cost component data needed in the overall analysis of the grains subsector. Develop and coordiante a system of cost data that would be linked internally in grains sector and externally with other commodity sectors.

PROGRESS: Work continued during the year on development of marketing spreads and cost components for producing and processing various commodities. Cost components for bread were estimated and

published for 1974. Estimates of 1974 energy use in grain production were completed in cooperation with other CED Program Areas and NEAD. Evaluation of alternatives for conserving energy in drying grain was also essentially completed. Work was initiated to analyze energy conservation practices in other aspects of grain production.

SUPPORTED BY U.S. Dept. of Agriculture, Economics Statistics & Cooperatives Service, Commodity Economics Div.

3.0039,

COST COMPONENTS AND MARKETING MARGINS

W.F. Lagrone, University of Nebraska, Lincoln Campus, U.S. Dept. of Agriculture Commodity Economics Div., Grains Program Area, *Lincoln, Nebraska* 68503 (CE-04-032-31-01)

OBJECTIVE: Estimate cost components by geographic areas for all phases of production, processing, and handling of grain. Develop a system for maintaining and updating cost data.

APPROACH: Estimate cost component data needed in the overall analysis of the grains subsector. Develop and coordinate a system of cost data that would be linked interally in grains sector and externally with other commodity sectors.

PROGRESS: Work continued during the year on development of marketing spreads and cost components for producing and processing various commodities. Cost components for bread were estimated and published for 1974. Estimates of 1974 energy use in grain production were completed in cooperation with other CED Program Areas and NEAD. Evaluation of alternatives for conserving energy in drying grain was also essentially completed. Work was initiated to analyze energy conservation practices in other aspects of grain production.

SUPPORTED BY U.S. Dept. of Agriculture, Economics Statistics & Cooperatives Service, Commodity Economics Div.

3.0040,

GEOTHERMAL ENVIRONMENTAL IMPACT ASSESSMENT - PLANTS AND SOILS

K.W. Brown, U.S. Environmental Protection Agency, Office of Research & Development, Environmental Monitoring & Support Lab., Pollutant Pathways Branch, *P.O. Box 15027, Las Vegas, Nevada* 89114 (J624B-62)

OBJECTIVE: Conduct environmental assessment of geothermal energy extraction activities by studying pollutant levels and population characteristics in preoperational and post operational modes.

APPROACH: Soil and plant samples will be collected prior to geothermal power plant operation to assess baseline levels of pollutants. Samples will also be collected after power plant operation. In addition, characteristics of plant populations will be ascertained such as species mix and biomass. Two distinct ecotypes will be studied. One is an intensive agricultural area in the Imperial Valley of southern California and the other a range land area near Roosevelt Hot Springs, Utah.

OUTPUT: Plant and soil sampling has been conducted at four KGRA's in the Imperial Valley and one KGRA at Roosevelt Hot Springs. AA analyses of samples has begun.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Environmental Monitoring & Support Lab.

3.0041,

DEVELOPMENT OF A STRATEGY FOR MONITORING CONTAMINATION OF PLANTS, ANIMALS, AND SOILS BY STUDYING AREAS IN ROOSEVELT HOT SPRINGS, UT

G.D. Potter, U.S. Environmental Protection Agency, Office of Research & Development, Environmental Monitoring & Support Lab., *P.O. Box 15027, Las Vegas, Nevada* 89114 (J624B-64)

OBJECTIVE/APPROACH: Develop a biological monitoring strategy by making a biological baseline assessment for Roosevelt Hot Springs geothermal resource area; by collecting and analyzing plants, animals, and soils for pollutants known to exist in geothermal effluents. Species and populations will be identified.

FINAL OUTPUT: Report on recommended biological monitoring strategy to be used by Federal, State, and local governments to monitor the effects of geothermal resource development.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Environmental Monitoring & Support Lab.

3.0042,

GEOTHERMAL ENVIRONMENTAL IMPACT ASSESSMENT - FAUNA

W.W. Sutton, U.S. Environmental Protection Agency, Office of Research & Development, Environmental Monitoring & Support Lab., *P.O. Box 15027, Las Vegas, Nevada* 89114 (J624B-61)

OBJECTIVE: Biological samples are collected at geothermal sites and analyzed for selected elements. The objectives will be to (1) provide baseline information prior to full scale energy production and (2) to examine the feasibility of using animals as biological monitors for geothermal pollutants. Rodents, rabbits, chickens and beef cattle represent various aspects of the field sampling program. The relative abundance/density of various wildlife species is also being investigated.

APPROACH: Field collected samples are transported back to Las Vegas and will be analyzed for such elements as lead, arsenic, zinc, and cadmium. Concurrent laboratory studies are designed to confirm tissue retention characteristics (or complicating homeostatic factors) for geothermal elements following quantitated oral exposures. These laboratory experiments serve as an essential part of the quality assurance effort and the laboratory generated samples will be analyzed by those techniques used for the field collected tissues.

OUTPUTS: Samples have been collected from Roosevelt Hot Springs, Utah and from Imperial Valley, California. Relative abundance work on small mammal populations at Roosevelt Hot Springs is also in progress. Analytical data on the field collections, and associated laboratory studies, are not available but should be reported next year.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Environmental Monitoring & Support Lab.

3.0043,

PROGRAMMING ENERGY USE ADJUSTMENTS IN NEVADA

W.O. Champney, University of Nevada, Reno Campus, Agricultural Experiment Station, Dept. of Agriculture & Resource Economics, *Reno, Nevada* 89507 (NEV00227)

OBJECTIVE: Develop energy use coefficients for crop and animal enterprises in Nevada. Collect cost data for each energy input. Estimate the potential substitution of alternataive energy sources as an explicit input. Derive least cost energy enterprise combinations.

APPROACH: Energy used on Nevada enterprises will be included in linear programming models to find least cost or optimum profit operations. These solutions will be examined to show what possible adjustments farmers and ranchers could make in forecasted cost increases of conventional energy sources.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Nevada

3.0044,

NEVADA GEOTHERMAL RESOURCE AREAS - A PRELIMINARY BIOLOGICAL SURVEY

J.L. Mahoney, University of Nevada, System Office, Desert Research Inst., *Reno, Nevada* 89507

Numerous geothermal springs and wells occur in Nevada and there is increased interest in exploration and exploitation of these resources for energy use. Areas have been characterized geologically and chemically, but no biological studies have been made to assess the existing flora and fauna of the various sites. This project will inventory the microorganisms, algae, higher plants, invertebrate and vertebrate animal communities of selected geothermal and hot spring areas. Present and potential use of each area will be considered along with a review of past and present research on Nevada's geothermal lands. Baseline data will be compiled for future use in environmental assessment of geothermal resource development.

SUPPORTED BY U.S. Dept. of the Interior, Office of Water Research & Technology

3.0045,

ECOLOGICAL INVESTIGATION OF DRY GEOTHERMAL ENERGY DEMONSTRATION

K.H. Rea, U.S. Dept. of Energy, Los Alamos Scientific Lab., Environmental Studies Group, *P.O. Box 1663, Los Alamos, New Mexico* 87544

Seasonally sample the various communities and identify any agents responsible for community change and identify the mechanisms by which they operate.Results of this investigation will lead to refined procedures for the mitigation of ecological imports due to development of hot, dry-rock geothermal resources. Many questions regarding the bioenvironmental consequences of such installations will be answered, and comparisons will be able to be made between the ecological impacts of this and other energy-producing systems.(1) 9-1-76 First integrated report of flora, fauna, and climatological parameters. (2) 9-1-77 First predictions as to rates of change. (3) 5-1-78 Implementation of fully automated weather monitoring equipment.

SUPPORTED BY U.S. Dept. of Energy, Div. of Biomedical & Environmental Research

3.0046,

WIND ENERGY SUBSTITUTION AT DAIRY MILKING CENTER

W.W. Gunkel, Cornell University, Ithaca Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Ithaca, New York* 14850 (NYC-123335)

OBJECTIVE: Construct a wind turbine at the Cornell Dairy Research Farm using a commercially available unit. Design and construct a system to provide direct water heating through churning action in an enclosed container. Collect wind speed data at the site. Collect data to measure the effectiveness of the wind turbine conversion system.

APPROACH: The researchers will cooperate with a commercial wind turbine manufacturer to erect a wind turbine with blade or propeller diameter of approximately 32 feet. Engineering analysis will be conducted to design the blades to be used in the liquid churn to match the output of the wind turbine for optimum operation. The churn will be constructed and a full scale pilot demonstration system will be developed and tested.

PROGRESS: Investigations of the use of wind energy to heat water directly through fluid friction were started. The hot water produced will be used at the Cornell Dairy Milking Center. Wind instrumentrs including wind direction and speed recorders as well as wind spectrum analyzer have been installed at the site and continuous wind data obtained. An extensive literature survey of water friction and stirring devices has been completed. Dimensional analysis of a water heating device has also been completed. Laboratory equipment to measure power input to the heating device was assembled and data has been collected for one model of a fluid friction heating device. The power dissipated by this model confirmed the expected cubic relationship between power and impeller rotational speed at Reynolds numbers of 15,000 to 500,000. Additional heating device tanks are being constructed. These will be used to measure the effect of several variables on power number. A three-bladed vertical axis wind turbine has been purchased. This turbine will be installed at the Dairy Center. Results of wind tunnel tests conducted on scale models of the site buildings were used to determine the specific location of the wind turbine. A system study of hot water requirements in a typical dairy operation is being conducted. Results of this study will be used to match the heated water output of the direct wind energy conversion device sized to the specific size of the wind turbine and expected wind at the site.

SUPPORTED BY New York State Government

3.0047,

ENERGY UTILIZATION IN AGRICULTURE

D.R. Price, Cornell University, Ithaca Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Ithaca, New York* 14850 (NYC-123310)

OBJECTIVE: Assess the technology used in agriculture production and the effects on energy consumption per unit of food and fiber produced. Investigate techniques for reducing energy demands in the food production chain. Collect data on energy consumption for various production units.

APPROACH: Use techniques of system analysis to evaluate the technology now employed for food and fiber production. From the literature and from measurements, data will be assembled to identify energy consumption for production units.

PROGRESS: Experiments were conducted to measure the efficiency of the savonious wind turbine. The efficiency was found to be approximately 16%. Windspeed measurements were recorded at two locations near Ithaca and it was determined that average windspeeds are well below 10 mph. Experiments were conducted to evaluate various techniques for reducing water heating requirements for washing and sanitizing milk handling equipment. Recycling techniques developed allowed water heating savings of nearly 40% and total water use was reduced by about 60%. Energy consumption for agricultural production in New York State was documented. The fuel use was determined on gallons per acre basis for crops, gallons per square foot for greenhouse heating and gallons per animal unit for livestock production. The total estimated fuel use for New York State agricultural production on the farm was 67,762,000 gallons.

SUPPORTED BY New York State Government

3.0048,

WIND ENERGY SUBSTITUTION AT DAIRY MILKING CENTER

D.R. Price, Cornell University, Ithaca Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Ithaca, New York* 14850 (3090-20401-002-C)

OBJECTIVE: Determine the feasibility of heat generation from wind energy by fluid friction heating and measure the performance of an experimental system designed to generate heat by this means.

APPROACH: The research will be done in the following manner: One or more models of a fluid friction energy converter will be constructed and tested to determine power as a function of operating speed and design variables. A wind turbine will be constructed near the dairy milking center. A full-size converter will be constructed and connected to the wind turbine. A wind turbine and fluid friction converter system will be used to heat water for a year, and performance measured, along with wind velocities and other environmental and operating variables.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Mid Great Plains Area

3.0049,

AUTOHEATED AEROBIC THERMOPHILIC DIGESTION WITH AIR AERATION

W.J. Jewell, State University of New York, Binghamton Campus, Graduate School, *Vestal Parkway, Binghamton, New York* 13901 (C611B-7065)

The federal water pollution control laws encourage the application of sewage sludge to agricultural land and for other beneficial uses as the preferred solution to this ultimate disposal problem. Because of the high capital and energy costs of reliable sludge treatment and disinfection, less costly and simpler treatment alternatives are being sought. Thermophilic aerobic digestion of sewage sludge offers promise of improving sludge management at a low cost. The possibilities of using the heat released during microbial oxidation of the sewage sludge to autoheat the waste liquid sludge has been considered by a number of investigators. The heat of oxidation of organics appears to be capable of autoheating sewage sludge at 95 to 97% water content to the thermophilic range only if the aeration system can achieve an oxygen transfer efficiency greater than 15%. Since most conventional aerators achieve transfer efficiencies less than 5%, it has been suggested that aeration with oxygen enriched air or pure oxygen would be necessary to support the concept of autoheating. Presently, a full scale commercially available unit being operated by Cornell University has been shown to be able to achieve thermophilic temperatures with a single air aeration system using autoheating with a mixture of a primary and secondary sewage sludge. Continuation of this study will document the limitations of the process and effectiveness of pathogen kill obtained with the autoheated temperatures.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Municipal Environmental Research Lab.

3.0050,

ENVIRONMENTAL STUDIES RELATED TO THE OPERATION OF WIND ENERGY CONVERSION SYSTEMS

S.E. Rogers, Battelle Memorial Inst., Columbus Laboratories, *505 King Ave., Columbus, Ohio* 43201 (E(11-1)-0092)

The overall objective of the second year of the effort is to place these effects in proper perspective to natural perturbations in the environment. Specific objectives are to (1) use MOD-0 wind turbine to provide parameters regarding sun exposure, rainfall and wind speed near a wind system and to establish the potential for secondary effects on the microclimate and biota, and (2) study the effect of rotating blades on airborne organisms, particularly migratory birds, by performing visual and radar surveys at Plum Brook during the fall and spring migrations. (ERDA-77-32)

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

3.0051,

DYNAMICS OF ENERGY UTILIZATION FOR HOMEOTHERMY AND PRODUCTION IN SWINE

D.P. Stombaugh, Ohio Agricultural Research & Development Center, *Wooster, Ohio* 44691 (OHO00456)

OBJECTIVE: Develop dynamic simulation models describing the basic mechanisms responsible for homeothermic and nutritional responses in swine; examine the role of hypothalamic and skin temperatures in controlling metabolic, vasomotor and respiratory defenses to thermal stress.

APPROACH: Nutritional data will be obtained from the literature. Data for the thermoregulatory model will be obtained experimentally. Control of hypothalamictemperatures using chronic implantable thermodes, the application of various ambient temperatures, monitoring hypothalamic, rectal and skin temperatures, respiratory and skin evaporative heat losses and oxygen consumption and utilizing control system testing techniques with a detailed model should allow a quantative description of the thermoregulatory control system.

PROGRESS: Data obtained from thermoregulatory studies on swine, 5-10 weeks old, have been analyzed and submitted for publication. Cold stress increased heat production 4.4 W/m for each 1 C decrease in ambient temperature. Vasomotor response were maximally developed at 25 C and remained effective as the severity of cold stress increased. During heat stress pigs were maximally vasodilated at both 35 and 37.5 with increases in respiratory frequency to 156 min . Internal body temperatures varied systematically with ambient temperature. Following feed consumption respiratory quotients increased and then decreased at 15, 25 and 35 C. The maximum duration of this response was two hours. At 35 C this heat increment was apparent and prolonged. Thermoregulatory changes following feed intake were small but consistent with other results. Transient data from control system testing procedures are being analyzed to obtain transfer functions relating metabolic rate, respiratory heat loss and vasomotor responses to changes in hypothalamic temperature at different skin surface temperatures. Preliminary work is being completed on the development of a simulation model describing food intake, the partitioning of energy and animal growth. This model will be combined with animal production models to optimize production costs and energy utilization. A new environmental control system for warm confinement animal housing utilizing subsurface energy extraction and dispersal has been proposed.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Ohio

3.0052,

ENERGY CONVERSION, ENERGY STORAGE AND RECONVERSION

W.L. Hughes, Oklahoma State University, School of Electrical Engineering, Dept. of Engineering, *Whitehurst Hall, Stillwater, Oklahoma* 74074

DESCRIPTION: To develop a family of systems for storing electrical energy and thereafter re-utilize the stored energy in various ways. In storage, major emphasis has been on the development of high-pressure (1000 to 3000 PSI) moderate temperature (300 to 400 degrees F) electrolysis cells, fuel cells and rechargeable fuel cells for the storage of electrical energy in the form of high-pressure hydrogen gas (other alternatives include hydrides and liquid hydrogen). The stored hydrogen can be used in many ways: mechanical output: hydrogen engine, Aphodid burner turbine; electrical output: fuel cells, high-speed turbine driven field modulated generator system; heat output: burners; synthetic fuel output: conversion of organic materials to hydrocarbon fuels. In reconversion, the emphasis at present is to develop a family of variable-speed constant (or adjustable) output frequency alternators by applying the field modulated frequency down conversion principle. These alternators will be driven at high speeds (around 10,000 RPM or higher) and consequently will be much smaller in size than conventional alternators of similar capabilities. Application of field modulated frequency down converters for variable speed mechanical inputs such as aeroturbines (wind energy systems) and for variable speed drive applications such as urban cars and prime-mover carrying mass transportation systems are currently being studied.

ADDENDA: Estimated calendar year funding reported as 1975 $20,000.

SUPPORTED BY Oklahoma State University

3.0053,

ENERGY CONSERVATION IN DRYING LUMBER AND VENEER

S.E. Corder, Oregon State Higher Education System, Oregon State University, Agricultural Experiment Station, Dept. of Forest Products, *126 Agriculture Hall, Corvallis, Oregon* 97331 (ORE-F-00026)

OBJECTIVE: Evaluate the technical and economic feasibility of: Drying lumber with forced air combined with supplemental heating, using a steam-jet heat recovery system with a high-temperature kiln, modifying veneer-drying systems for reduced energy consumption, and recovery of energy from the exhaust of a veneer dryer.

APPROACH: First perform calculations and analysis to predict performance of the proposed systems. Tests will then be conducted to verify performance and to help define operational problems which might develop. Energy savings will be identified and results of the findings will be publicized.

PROGRESS: A literature search has been initiated. Preliminary calculations have been made to determine supplemental heat requirements for forced-air drying of lumber. Several possible methods for improving the air seal at the ends of a veneer dryer have been formulated.

SUPPORTED BY Oregon State Government

3.0054,

AGRICULTURAL STRUCTURES DESIGN UTILIZING ALTERNATE ENERGY SYSTEMS, MATERIALS AND CONCEPTS

M.L. Hellickson, Oregon State Higher Education System, Oregon State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *126 Agriculture Hall, Corvallis, Oregon* 97331 (ORE00360)

OBJECTIVE: Evaluate the overall heat transfer coefficients for single-layer polyethylene, double-layer polyethylene, flat and corrugated fiberglass. Compare the heat transfer characteristics of typical greenhouse structural designs including arched and gabled roofs. Design, construct and test a compact energy converter for accepting rotary shaft power from a windmill. Design and develop structures for lambing in high winter rainfall climates.

APPROACH: Construct model size greenhouse structures with various glazing surfaces that can be laboratory tested to evaluate the overall heat transfer coefficients. Construct a prototype mechanical to thermal energy converter and test as to energy input requirements, associated torque necessary to operate and evaluate quantity and temperature of water circulate through the apparatus. Test variable structural designs that will provide optimum environmental conditions for lambing ewes and newborn lambs reared in a high winter rainfall climate.

PROGRESS: Significant progress has been made in the analytical comparison of the heat transfer characteristics of typical greenhouse structural designs (arched versus gabled roof construction) and in comparison of the overall heat transfer coefficients of polyethylene, glass, corrugated fiberglass and flat fiberglass. Preparation of physical test specimens for laboratory determination of comparative heat transfer characteristics of corrugated versus flat fiberglass is in process. Considerable interest in this study has been shown throughout Oregon and especially in the Klamath Basin. Development of a mechanical to thermal energy converter has progressed through two modifications of the original concept. Further physical modification of the apparatus is scheduled

before pertinent data on torque, rpm and heat generation can be recorded.
SUPPORTED BY Oregon State Government

3.0055,
8 KW TURBINE GENERATOR DEVELOPMENT 3-BLADED DARRIEUS

B. Stemler, Aluminum Co. of America, Alcoa Labs, *425 6th Ave., 1501 Alcoa Bldg., Pittsburgh, Pennsylvania* 15219 (E(29-2)-3533)

The peak demand for an average home without electrical heating is approximately 8 kW. A wind system of this size would have wide application to powering homes or farm buildings. The goal of this program is to challenge industry to produce an 8 kW wind system at an initial cost to the user of $750 per installed kW, excluding batteries, inverter, or other secondary components. This two-phase program requires: (1) design and analysis of complete systems capable of producing 8 kW in a 20 mph wind and delivery of working drawings,and (2) construction of prototype machines and delivery to Rocky Flats for testing and evaluation. This project is a subcontract. (DOE/ET-0023/1)
SUPPORTED BY Rockwell International Corp.

3.0056,
ENERGY RECOVERY FROM DAIRY SYSTEMS

H.D. Bartlett, Pennsylvania State University, University Park Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *201 Shields Bldg., University Park, Pennsylvania* 16802 (PEN02334)

OBJECTIVE: Develop and evaluate systems for recovering heat from dairy barn ventilation and milking systems.
APPROACH: A heat recovery system using 'heat pump' principles will be developed for capturing surfaces will be employed to absorb heat from the ventilation by cooling the air and condensing moisture; captured heat will be transferred through water cooled condensers to a hot water storage tank. Evaporator design will incorporate means to minimize dust fowling and/or to simplify procedures for removing dust accumulation. Following development of operational systems, heat transfer coefficients, net energy recovery and capital costs will be determined. In additon, heat recovery by the use of newly developed watercooled condensers for milk cooling equipment will be evaluated in relation to energy saving.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Pennsylvania

3.0057,
CLIMATIC RESOURCES OF THE NORTH CENTRAL REGION

W.F. Lytle, South Dakota State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Brookings, South Dakota* 57006 (SD00565)

OBJECTIVE: Define Mathematical models for assessing the potential effects of Weather Modification in specific areas of the North Central Region. Delineate by graphs, maps, and tables the climatic variation in windy pan evaporation, evapotranspiration, soil temperature, and cumulus clouds in the North Central Region and compute parameters that will describe probabilities of these data.
APPROACH: By step-wise multiple regression techniques find the relationship between crop yield, quality, and various climatic variables. This type of research was started on a project started for the Bureau of Reclamation and should be further refined and different climate variables explored that were not used before. Use all the possible models of rainfall increase suggested by researchers in Weather Modification experiments to predict from historical rainfall all the possible amounts of rainfall increase that could occur in the various climatic parts of the region. Continue a pilot study analysis of wind data that would be helpful to determination of energy potential available throughout the North Central Region. Analyze the pan-evaporation data available in terms of the climatic variables that effect the readings and determine relationship to evapotranspiration data.
PROGRESS: Thirty stations from the South Dakota Climatical Data were put through the computer to give 'Growing-Degree Days' data for a North Central Regional Publication. The publication will be coming out from Iowa State Experiment Station. I have been on the Editorial Committee for a publication 'Solar Radiation Reception, Probabilities, and Areal Distribution in the North Central Region' which will be coming out from the Minnesota Experiment Station. Study of Wind Analysis in South Dakota in previous years has lead to a new project to develop a North Central Regional Project on Wind Analysis that would determine the probabilities of various amounts of wind energy becoming available across the North Central Region. A detailed study is being conducted of all literature available and formulation of a comprehensive plan for processing all the wind data in the North Central Region. Cooperative work with climatologists from Minnesota and North Dakota will lead to analysis and publication of data on evaporation, soil temperature, and moisture balance in these states.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, South Dakota

3.0058,
UTILIZATION OF WIND ENERGY FOR PUMPING IRRIGATION WATER FROM WELLS

A.D. Schneider, U.S. Dept. of Agriculture, Agricultural Research Service, Southwest Great Plains Research Center, *Bushland, Texas* 79012 (7315-20741-002)

OBJECTIVE: Evaluate the performance of a wind rotor for driving an irrigation pump; develop irrigation pumping equipment that can be effectively driven by a wind rotor; determine economic feasibility of wind powered irrigation pumping systems; develop a computer model of a vertical axis wind rotor.
APPROACH: A wind rotor will be installed near an existing water well. The wind power into the rotor and the power delivered to the pump will be measured to determine efficiency. Commercially available pumps will be modified as necessary to attach them to the unsteady power input. Four types of pumps will be evaluated--air lift, turbine, positive displacement piston, and positive displacement rotary. Cost comparisons will be made with pumping an equal amount of water by present energy sources. A computer model of a vertical axis wind rotor will be developed so that the performance of the wind machine can be simulated over long-time periods and with different wind regimes.
PROGRESS: A hybrid, wind turbine-electric motor driven irrigation pumping system was designed, and all equipment and instrumentation were selected and ordered. A vertical-axis wind turbine and electric induction motor will be coupled with a combination gear drive to power vertical turbine pump. An extensive data collection system was designed to measure available wind power, wind turbine power, electric power, and water output of the pump. Sufficient data sensors were selected to permit calculating the efficiency of all major components in the system. The data will also permit the verification of wind turbine models by a research cooperator.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Oklahoma - Texas Area

3.0059,
GEOTHERMAL DEVELOPMENT IMPLICATIONS

Unknown, University of Texas, Austin Campus, Graduate School, *200 W. 21st, Austin, Texas* 78712 (WELUT NO. 034-76)

An assessment will be made from existing information of the potential for development of this energy resource and its extent; and, identification of fish and wildlife impacts to be anticipated from development. Development alternatives, mitigation options, sensitive ecological areas, and research needs will also be identified.
ADDENDA: Project Officer: Ed Pash.
SUPPORTED BY U.S. Dept. of the Interior, Fish & Wildlife Service, Office of Biological Services

3.0060,
RURAL COMMUNITY AND AGRICULTURAL PROBLEMS: ASPECTS

R.A. Christensen, Utah Higher Education System, Utah State University, Agricultural Experiment Station, Dept. of Agricultural Econ, *Main Bldg., Room 104, Logan, Utah* 84321 (UTA00009)

OBJECTIVE: Analyze rural community and agricultural economic problems in Utah and disseminate statistical and other decision-making information.
APPROACH: Much of the work will be in response to requests for assistance in solving problems by various agricultural groups and leaders in the state. Procedures for each phase of work will be determined prior to the initiation of the research. Reports for federal, state, and local government agencies will be assembled and analyzed. Special studies based on these data will be published periodically. Studies will also be made evaluating various governmental and private programs with regard to their limitation, effects on the economy of Utah, and ability to achieve specified goals.
PROGRESS: Origin and migration patterns of rural Utah manufacturing workers were analyzed. The results show that 57 percent of the workers studied had lived in the state during their youth, left the state during early adulthood, and then returned to take up manufacturing jobs as they opened up in rural Utah. A comparison of present job locations with immediately previous job locations showed that of the present rural Utah manufacturing work force, 3 percent came from the rolls of the unemployed, 23 percent from in-migration, 12 percent from commuters from nearby counties, 10 percent from new work force entrants, and 48 percent from the existing rural Utah work force. Other progress included beginning an analysis of patterns of farm land transfer from one generation to the next, preparing an economic outlook for the cheese industry, beginning a study of the cost and function of providing the market with reserve supplies of grade A milk for fluid consumption, advising the State Tax Commission on the administration of the Utah Farmland Assessment Act, publishing cost of producing crops on irrigated lands in Utah, working with the USU Foundation to assess the feasibility of utilizing geothermal water in the dairy industry in the west, and irrigating land in Boyd County, Nebraska using water from the Boyd County pumped storage project, comparing price changes for milk and dairy products with price changes for inputs used in the dairy industry.
SUPPORTED BY Utah State Government

3.0061,
GEOLOGICAL AND GEOPHYSICAL REMOTE SENSING OF ICELAND

R.S. Williams, U.S. Dept. of the Interior, Geological Survey, Land Inf & Analysis Office, *12201 Sunrise Valley Dr., Reston, Virginia* 22092

Research objectives for FY 77 fall into 4 major disciplines: glaciology, cartography, geothermal, and rangeland mapping. Primary emphasis will be placed on glaciological studies in Iceland including comparison of glacier area on previously published maps with Landsat imagery. Cartographic work will involve the publication, in February 1977, of a 1:500,000-scale, false-color image format map of the world's largest temperate glacier, Vatnajokull, Iceland. A companion, black and white image map may also be published. Two or three special 1:250,000-scale maps (including a JPL, computer-enhance version) of Vatnajokull will be prepared as I-maps during FY77 and will include a substantial test. Geothermal studies will involve the preparation of a U.S. Geological Survey Professional Paper, 'Remote Sensing of High-Temperature Geothermal Areas of Iceland'. It will be prepared jointly with Icelandic National Energy Authority and will include aerial photographs, aerial thermographs, and satellite images of the 17-high temperature geothermal areas of Iceland. A comprehensive bibliography of the literature of the geothermal areas of Iceland will be included. Rangeland mapping on Landsat imagery, using the Image 100, will include mapping the vegetative cover and species delineation of an already mapped area, which has been undergoing severe erosion.
SUPPORTED BY U.S. Dept. of the Interior, Geological Survey, Office of Land Information & Analysis

3.0062,
APPLICATION OF WINDMILLS TO APPLE COOLING AND STORAGE

D.H. Vaughan, Virginia Polytechnic Inst. & State University, School of Agricultural & Life Sciences, Dept. of Agricultural Engineering, *Blacksburg, Virginia* 24061 (VA-0331924-1)

OBJECTIVE: Field test an apple cooling and storage facility using a windmill to provide the energy required. Document windmill performance, total system performance, and wind and weather variations. Conduct economic and cost analyses of the tested windmill application to assess the utility and attractiveness of the system in light of the test results and projected advances in windmill technology.
APPROACH: Meteorological measurements, including windspeed, will be made in order to select a site which has 'good' wind energy availability. A state-of-the-art apple cooling facility (including building and refrigeration equipment) will be designed to be used as a test bed for the windmill application. The building will have energy conserving measures such as extra insulation. A commercially available windmill will be selected to match the cooling requirement and purchased. Two methods of thermal energy stor-

age will be used. Batteries will be used to store the electrical energy generated by the windmill generator. Electrical energy from the batteries will power the refrigeration system, which will be used to make ice in a tank/thermal exchanger. The ice tank will be used for cooling purposes, especially during the high cooling load period when the apples are loaded into the building. The windmill application will be fully instrumented to recorded windmill parameters, weather, apple environment, and cooling system performance.

SUPPORTED BY Virginia State Government

3.0063,

APPLICATION OF WINDMILLS TO APPLE COOLING AND STORAGE

J.A. Schetz, Virginia Polytechnic Inst. & State University, School of Engineering, Dept. of Aerospace Engineering, *Blacksburg, Virginia* 24061 (1090-20191-005-C)

OBJECTIVE: Design, construct, andoperate a windmill power generating system to cool and store apples; measure the performance of the system as it relates to local wind conditions; and make an economic, cost, and value analysis of wind utilization in cooling and storing of apples.

APPROACH: The research will be conducted by aseries of tasks as follows: Take preliminary meteorological measurements at the site. Design an apple cooling plant for 2,000 bushels of apples. Specify and order commercial windmill. Build the apple cooling plant. Install the windmill. Perform preliminary field measurements of the system in operation. Conduct wind tunnel tests for perfromance. Conduct main field measurements for performance of the total system. Perform economic and cost analysis of system. Prepare final report.

PROGRESS: A 22.5-foot diameter, horizontal wind turbine was installed near the Virginia Polytechnic Institute and State University campus on a 90-foot tower. Power produced by the wind turbine was measured over the range of wind velocity of 2 to 8 m/s. Power was measured using either a resistant load or a battery load. After testing was completed, It was moved to a site to be used to supply power to an apple storage facility. A refrigeration system was designed and installed in a modified apple storage building. The refrigeration system includes a cold storage capacity that will be used with the wind turbine. Several varieties of apples have been stored in the building.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research Service, Beltsville Agricultural Research Center

3.0064,

EVALUATION OF A WIND ENERGY CONVERSION SYSTEM FOR AGRICULTURAL APPLICATION

C.F. Becker, University of Wyoming, Agricultural Experiment Station, Dept. of Agricultural Engineering, *P.O. Box 3944, University Station, Laramie, Wyoming* 82071 (WYO-148-078)

OBJECTIVE: Secure meterological data and correlate with performance of a wind energy conversion system (WECS) as related to agricultural farmstead electrical energy needs.

APPROACH: A computer direct digital data acquisition system to monitor wind speed and direction, other meteorological data, electrical consumption used for water heating, home use, feed grinding and other uses at the University of Wyoming Dairy Farm will be constructed to record the data on magnetic tape and display the information in real time for decision making and control. Information on energy received from and supplied to the utility energy grid will also be secured. Energy requirements for various applications and performance of the WECS will be correlated with meteorological parameters.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative State Research Service, Wyoming

3.0065,

STUDY COVERING THE INTENSIVE AGRICULTURE-FOOD PRODUCTION WITH THE GOAL OF CORRELATING ENERGY FACTORS AND ENVIRONMENTAL IMPACT

R.H. Hall, McMaster University, Dept. of Biochemistry, *1200 Main St. W., Hamilton, Ontario, Canada* L8S 4L8

No summary has been provided to the Smithsonian Science Information Exchange.

SUPPORTED BY Dept. of the Environment

3.0066,

WIND POWER FOR HEATING AGRICULTURAL BUILDINGS

Unknown, Den Kongelige Veterinaer og Landbohojskole, Agricultural Engineering Inst., *Bulowsvej 13, DK1870 Copenhagen, Denmark*

The initiative for this research was taken shortly after the oil crisis, among other things, after various applications by farmers for alternative power sources. From other activities, the Institute had experience with the so-called 'water brake' or hydraulic dynamometer, where the mechanical energy is utilized in connection with the measurement of the power output of tractors. Here the combination of wind driven motor with an hydraulic dynamometer becomes obvious.

The principal purpose of the research is to determine whether the described method will prove itself functionally and economically in the case of the heating of water in a central heating plan and production of water for use.

SUPPORTED BY Government of Denmark

3.0067,

EXPLOITATION OF GEOTHERMAL ENERGY IN AGRICULTURE

D. Pasternak, Research & Development Authority, *Beersheva, Israel*

The exploitation of geothermal water for soil warming is being investigated.

Experiments are being carried out on cucumbers, melons and watermelons to determine the effect of soil warming with geothermal water on their growth.

SUPPORTED BY Ministry of Commerce & Industry

3.0068,

EARTH HEAT PUMPS

K.G. Eriksson, Chalmers Tekniska Hogskola, Dept. of Geology, *S40220 Goteborg 5, Sweden*

Efforts to conserve energy have increased the interest in heat pumps for heating buildings. Outdoor air is frequently used as a heat generator in existing heat pump plants but several factors indicate that a solution with heat absorption from the earth would be a suitable form, particularly for Swedish conditions. The aim of this project is to clarify the prerequisites for using earth heat pumps in Sweden with regard to geological, heating and house construction engineering conditions, taking economic and operational factors into consideration.

The following will be studed in the project: 1. Various location alternatives for the heat absorber. 2. Possibilities for using earth heat pumps for higher building intensities than those involved in one-family houses of today. 3. Possibilities for installing earth heat pumps in existing housing.

SUPPORTED BY Statens Rad for Byggnadsforskning

3.0069,

INVESTIGATION OF TECHNICAL/ECONOMICAL FEASABILITIES OF USING WIND ENERGY FOR HEATING PURPOSES WITHOUT GENERATION OF ELECTRIC POWER

I. Carlsson, Lutab Ingenjorsbyran Ab, *Snormakarvagen 29, S16147 Bromma, Sweden*

OBJECTIVE: To establish technical and economical feasabilities in using wind energy without energy conversion systems for heating purposes.

APPROACH: Studies of tentative designs for transforming mechanical energy into heat and the transportation of generated energy in order to heat a one-family size house.

Identification of technical and economical limitations of proposed system designs. Comparative analysis showing - partly the cost of utilized energy - partly cost/benefit from an individual utilizers point of view.

INTENDED USE OR RESULTS: The results will serve as the basis for decisions concerning future development of small scale wind energy conversion systems for local use in Sweden.

SUPPORTED BY Namnden for Energiproduktionforskning

3.0070,

UTILIZATION OF ENERGY RELEASED WHEN COOLING MILK

A. Martensson, Swedish University of Agricultural Sciences, Faculty of Agriculture, Farm Buildings, *Box 624, S22006 Lund 6, Sweden*

OBJECTIVE: When milk is cooled, thermal energy is released, which the individual farmer normally allows to go to waste. However, the energy wasted in this way may well be used to heat dish water, spaces where calves are kept, staff room, etc.

APPROACH: Various heating systems suitable for installation will be tested in actual operation and followed up by careful capacity measurements. Owing to peaks in connection with milking, it will be necessary to develop a system for storing of energy for space heating purposes.

PROGRESS: There is some equipment available on the market which may be employed for recovering the energy concerned but experiences in the use of such equipment are very limited. However, the Swedish dairies assocations have shown a great interest in possible applications.

INTENDED USE OF RESULTS: The aim is to prepare solutions which will be directly applicable to existing farm buildings.

SUPPORTED BY Styrelsen for Teknisk Utveckling

3.0071,

ECOLOGICAL EFFECTS OF EXTRACTION OF GEOTHERMAL ENERGY

T. Troedsson, Swedish University of Agricultural Sciences, Faculty of Forestry, Dept. of Forest Soils, *Box 7001, S75007 Uppsala, Sweden*

OBJECTIVE: To study the alterations in the ecological environment caused by the extraction of geothermal energy.

APPROACH: Full scale experiment to determine the effect on soil processes of varying extraction rates, primarily on garden plants.

Soil physics - measurements of energy flows and water flows within the test surfaces, using methods developed in the NFR project 'The Ecology of Coniferous Forest Country'. (NFR is the Swedish Natural Science Research Council.)

Soil chemistry - studies in this field lie entirely within the framework of traditional pedological methods.

Soil biology - the effects on the soil processes are gauged by various activity measurements. Soil breathing is measured continuously using portable gas chromatography equipment. Earthworms have been chosen for intensive study of their behavior at various extreme levels of extraction.

Cultivation conditions - the practical consequences of energy extraction for cultivation conditions are gauged by cultivating temperature-sensitive 'indicator plants'.

TODAY'S SITUATION: The methods of this project exist in theory, but not for 'average land for detached-house development'.

USE OF RESULTS: Ecological consequences of extraction of geothermal energy, mainly for detached-house development, also in principle for higher-density development.

SUPPORTED BY Statens Rad for Byggnadsforskning

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